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# ***JPRS Report***

# **Science & Technology**

***China***

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## SCIENCE &amp; TECHNOLOGY

## CHINA

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BEIJING POSITRON-ELECTRON COLLIDER NEARS COMPLETION

40080016a Beijing RENMIN RIBAO in Chinese 28 Sep 87 p 1

[Article: "The Beijing Positron-Electron Collider Nears Completion--Absorbing Advanced Foreign Technologies, Relying on Our Own Efforts To Manufacture the Equipment"]

[Text] Part of the earthworks have been basically completed now at the world famous Beijing Positron-Electron Collider construction project and the development and production of some of the large key equipment is finished. More than 90 percent of the equipment has been installed. The introduction provided by the relevant departments stated that this project was constructed by fully absorbing and digesting advanced foreign technologies and relying on our own efforts.

In 1984, the CPC Central Committee Secretariat decided to establish a leadership group composed of responsible comrades from the Chinese Academy of Sciences, the State Planning Commission, the State Economic Commission and Beijing Municipality.

Over the past three years, the project mobilized over 10,000 S&T personnel, workers and cadres from over 100 plants in more than 10 ministries and commissions to take part in the construction.

The information is that 70 percent of the primary equipment at the Beijing Positron-Electron Collider is special purpose non-standard equipment at international levels. This includes some of the large pieces of equipment and several tens of types of technically precise and complex special purpose equipment like high power pulse regulators, equal gradient accelerator tubes, high power pulse klystrons, large spectrographic magnets and so on that were developed and produced in China for the first time. The Chinese Academy of Sciences' Institute of High-Energy Physics and production departments united in cooperation and refused to back away from the many difficulties they faced.

Now the Beijing Positron-Electron Collider construction project is nearing completion and installation of the more than 200 meter long 1,400 MeV electron linear accelerator and the two bidirectional beam transport lines that together are more than 240 meters long has been finished. With the exception of the vacuum boxes and probes, all of the main equipment in the 240 meter circumference circular storage ring is being tested and adjusted. The Beijing Positron-Electron Collider already has successfully produced positrons on one occasion, which indicates that accelerator technologies in China have attained or approximated advanced international levels.

# CHINA'S NUCLEAR PHYSICS RESEARCH ENTERS NEW STAGE

40080016b Beijing GUANGMING RIBAO in Chinese 15 Aug 87 p 1

[Article: "China's First Accelerator Is Examined and Approved by the State-- Basic Research in Experimental Nuclear Physics in China Enters a New Stage"]

[Text] Basic research in experimental nuclear physics in China has entered a new stage. On 14 August 1987, at the Chinese Academy of Atomic Energy Sciences in the southwestern suburbs of Beijing, 15 experts from various fields solemnly signed their names and China's first large scale tandem accelerator physics laboratory project received state acceptance.

An accelerator is a facility which speeds up charged particles until they achieve extremely high speeds (comparable to the speed of light). It is an important piece of equipment for research on atomic nuclei and basic particles. The range of applications for accelerators in industry, agriculture, medicine and public health has continued to expand in recent years. Examples include ion mixing, industrial flaw detection, seed irradiation, radiation therapy and so on. A tandem accelerator is an important member of the accelerator family. It can accelerate protons, electrons and all types of heavy ions, and it is an effective tool at present for basic research on experimental nuclear physics as well as research on certain applications of nuclear technologies. It can be said that the presence or absence of a large scale tandem accelerator in a country is an important indicator for evaluating the level of development of atomic nuclei physics in that country.

China's newly-constructed large tandem accelerator has a terminal voltage of 13 MV and can accelerate particles in most of the elements in the periodic table. It has continuously regulable power and a high resolution ratio, and it is best suited for systematic, precise and accurate experimental research in nuclear physics. The main equipment in the accelerator was imported from the United States and the entire project was designed and built by China itself. To save foreign exchange and base long-term materials consumption on Chinese sources, with a prerequisite of assuring quality, the key components in the accelerator including the large steel cylinders, the sulphur hexafluoride insulating gas and other things were processed and manufactured on a trial basis by China itself.

It was learned that from the time it basically was completed and operational trials began in November 1986 up to the end of May 1987, the accelerator had provided 1,500 hours of beam time and had completed experimental equipment adjustment and two research projects concerning the fine structure of atomic nuclei. One project was carried out in cooperation with England's University of Manchester and was the first international cooperation project following completion of this accelerator laboratory. At the "Beijing Tandem Physics Conference" held in 1986, more than 30 physicists who had come to China from foreign countries felt that laboratory deployments and equipment outfitting were at advanced international levels, that the first group of topics had been chosen correctly, and that scientific research achievements at rather high levels could be possible.

12539/7310

CATHODE PROBLEM IN PULSED MAGNETRONS

40090022 Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese  
Vol 9 No 3, May 87 pp 193-204

[English abstract of article by Zhang Enqiu [1728 1869 5876] of the Institute of Electronics, Chinese Academy of Sciences]

[Text] There are two different expressions for anode currents of pulsed magnetrons: one, comprised of electric and magnetic parameters as well as tube geometries, describes how the electrons are picked up from the rotating electron stream near the anode space; the other, stating the relationship among thermal emission, the coefficient of back bombardment and the coefficient of secondary emission, is a general description for supplying electrons to the rotating stream by the cathode without concern for a particular tube. Each of the above expressions has its own physical significance, while they are closely connected through the rotating electron stream. The integration of these expressions with the electron motions in the interaction space leads to better understanding of the mechanism of magnetrons.

For stable operation of the magnetron, the preoscillation voltage should be lower than the threshold voltage, while the mode of this space charge oscillation should be the same as the  $\pi$  mode oscillation on the resonating cavities. After starting the resonance, if the thermal emission approximately equals the back bombarding current and the secondary emission approximately equals the anode current, good performance is indicated.

9717

COHERENT RADIATION OF MILLIMETER WAVE GENERATED BY INTENSE ANNULAR  
RELATIVISTIC ELECTRON BEAM

40090022 Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese  
Vol 9 No 3, May 87 pp 205-212

[English abstract of article by Yin Yuanzhao [1438 0337 2507], et al., of  
the Institute of Electronics, Chinese Academy of Sciences]

[Text] Properties of coherent radiation of millimeter waves generated by an intense rotating annular relativistic electron beam (E-layer) which is from a cusp magnetic field are investigated. The linearized Vlasov-Maxwell equations are used to analyze the interaction between the E-layer and the magnetron's resonator. The dispersion relationship is deduced and a numerical calculation is made. The results show that the frequency of microwave radiation is  $\omega_r$  ( $\omega_r = \ell \Omega_{11}$ , where  $\Omega_{11}$  is the electron relativistic cyclotron frequency in the axial magnetic field;  $\ell$  is the azimuthal mode number,  $\ell = n + mN$ ;  $N$  is the number of side resonators;  $n = 0, 1, 2, \dots, N/2$ ,  $m$  is any integer). The growth rate of radiation is still large enough, even if  $\ell$  is large. It is good for generating millimeter wave radiation at a low axial magnetic field. If the modes can be controlled well, a tunable, high power millimeter wave device can be made.

9717

OPTIMIZATION OF MAGNETIC DEFLECTION SYSTEM

40090022 Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese  
Vol 9 No 3, May 87 pp 221-228

[English abstract of article by Xie Zhixing [6200 1807 5887], et al., of  
Zhejiang University]

[Text] This is the second of two papers about designing the saddle deflection yoke with a ferromagnetic shield. Using the expressions of the field parameters given by the authors (1987) and with the aid of an orthogonal design method, the authors have optimized the design of the saddle deflection yoke with a ferromagnetic shield. The results obtained agree with the practical model. It is pointed out that the end-ear and the distribution of the field parameter  $B_0(z)$  have important effects on the deflection aberrations. An example is given that compares the electron optical properties of the deflection coils with cosine-distribution, and finite length with that of the deflection coils with distributed winding.

9717

DETECTION PERFORMANCE OF DIGITAL POLARITY SAMPLED PHASE REVERSAL CODED PULSE COMPRESSORS

40090022 Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese  
Vol 9 No 3, May 87 pp 269-272

[English abstract of article by Zhu Zhaoda [2612 0340 6671], et al., of  
Nanjing Aeronautical Institute]

[Text] The nonparametric constant false alarm rate (CFAR) property of digital polarity sampled phase reversal coded pulse compressors is described. The detection performance in Gaussian and non-Gaussian noise is determined. It is shown that the loss in signal-to-noise ratio of the processor, relative to the incoherent matched filter, decreases as the code length increases, the asymptotic loss in Gaussian noise is 1.96 dB, and the loss in Weibull noise decreases with the shape parameter of the Weibull distribution and can even become a gain.

9717



NUMERICAL ANALYSIS OF CRITICAL PENETRATION VELOCITY FOR JET PERPENDICULAR PENETRATION

40080018 Beijing LIXUE XUEBAO [ACTA MECHANICA SINICA] in Chinese Vol 19, No 2, Mar 87 pp 101-110

[Article by Qin Mengzhao [4440 1322 0340] of the Chinese Academy of Sciences Computing Center, Xie Chunsheng [6200 2504 3932] of the Ministry of Ordnance Industry and Tan Qingming [6151 1987 2494] and Liu Xiaoping [0491 1420 5393] of the Chinese Academy of Sciences Institute of Mechanics: "Numerical Research on Armor-Cracking Critical Penetration"\*]

[Text] Abstract: This article uses a computing program for two-dimensional non-steady fluid elastic-plastic material to calculate low-velocity jet flow penetration of steel target plates. It derives dynamic processes concerning the target plate pitting and steady penetration stages and confirms that Professor Zheng Zheming [6774 0772 2404] is correct regarding the mechanisms of metal penetration [1, 2]. In addition, it derives qualitative results for jet energy dissipation and the range of critical penetration velocities indicative of target plate resistance to penetration.

Key terms: jet flow, penetration, fluid elastic-plasticity, numerical calculations

# I. Introduction

To do numerical research on questions of impact and explosion, work began in 1972 on numerical calculations for two-dimensional non-steady fluid elastic-plastic material, and definite progress has been made. This article employs a HELP-type two-dimensional computing program[11] and a fluid elastic-plasticity mechanics model to calculate the penetration of a steel target plate by a metallic copper jet of infinite length and uniform velocity. The jet velocities were 850 m/s, 750 m/s, 650 m/s and 601 m/s. The target plate had an ordinary temperature and ordinary pressure dynamic load strength of  $10^3$  [MPa]. The calculations derived the jet velocity when the steady penetration velocity was zero. This is the critical penetration jet velocity

\* This project was recommended for a third-place PRC National Defense Industry Office award in 1980 by Mr Feng Kang [7458 1660].

(abbreviated below as the critical penetration velocity). In addition, calculations were made concerning a group of relevant parameters for changing target plate strength and solidity to check the computed results. These calculations were compared with the aforementioned calculation results and were found to meet the standards for dimensional analysis, indicating that the calculations had a definite reliability. Most of the parameters used in these calculations were taken from reference (5).

## II. Statement of Problem

The early part of the armor cracking process is a very short non-steady pitting stage. This is followed by a slowing of changes in penetration velocity, penetration pressure and penetration hole shape, and is basically a steady process. During this process, when the velocity of a certain jet micro-component is  $V_j$  and the penetration velocity of the target plate microcomponents at the bottom of the hole is  $V$ , the relationship  $V_j-V$  can describe the main characteristics of the process of armor cracking. Eichelberger[9], Tate[10] and others have used the formula for the relationship  $V_j-V$  given below to describe the high velocity penetration process:

$$\frac{1}{2} \rho_i (V_i - V)^2 = \frac{1}{2} \rho_i V^2 + R_t \quad (1)$$

In the formula,  $\rho_t$  and  $\rho_j$  are the target plate and jet densities,  $V_j$  is the arriving velocity of the jet flow,  $V$  is the penetration velocity at the bottom of the hole and  $R_t$  is the target plate resistance to penetration. Formula (1) is in essence a revision of Bernoulli's formula for degree of strengthening. It is assumed here that jet and target plate interaction during the penetration process is primarily fluidic, but the effects of target plate strength cannot be ignored. Professor Zheng Zhemín suggested[2] that full consideration must be given to the dynamic characteristics of strength, so formula (1) should be changed to:

$$\frac{1}{2} \rho_i (V_i - V)^2 = \frac{1}{2} \rho_i V^2 + KY_0 \left[ 1 + \alpha \left( \frac{\frac{1}{2} \rho_i V^2}{Y_0} \right)^{\mu/2} \right] \quad 0 < \mu \leq 1 \quad (2)$$

This formula contains three special coefficients,  $K$ ,  $\alpha$  and  $\mu$ .  $Y_0$  is the ordinary temperature ordinary pressure dynamic strength of the target plate material.

The target plate resistance to penetration  $KY_0$  changes with the penetration velocity  $V$ . Whether formula (1) or (2) is used, however, the critical penetration jet velocity of the target plate in both cases is:

$$V_j^* = \sqrt{\frac{2KY_0}{\rho_i}} \quad (3)$$

By assuming that no blockage occurs within the penetration hole during the penetration process and that the jet microcomponents continue to penetrate until the microcomponents at velocity  $V_j$  are incapable of further penetration of the target plate, the relationship  $V_j$ - $V$  can be described with formula (1) or formula (2).<sup>\*</sup> When using formula (1) or (2), however, the critical penetration velocity of the target plate material  $V_j^*$  must be determined, which often presents some problems in testing and analysis. The analysis in reference (2) states that  $V_j^*$  should be smaller than 1 km/s (for a target plate with a strength of  $10^3$  MPa). A numerical simulation method was used to derive the value of  $V_j^*$ . The simulation method involves calculation of the impact with the target plate of a jet of infinite length and uniform velocity at a velocity of 850 m/s, 750 m/s, 650 m/s and 601 m/s to derive the corresponding steady penetration velocity  $V$ . This is extrapolated to derive the corresponding jet velocity  $V_j^*$  when  $V = 0$ . To assure that the derived  $V_j^*$  reflects accurately the penetration resistance qualities of the target plate, the length of the jet and the dimensions of the target plate must be sufficiently large to avoid unnecessary boundary effects. The calculated graphics and boundary conditions when  $t = 0$  are shown in Figure A.

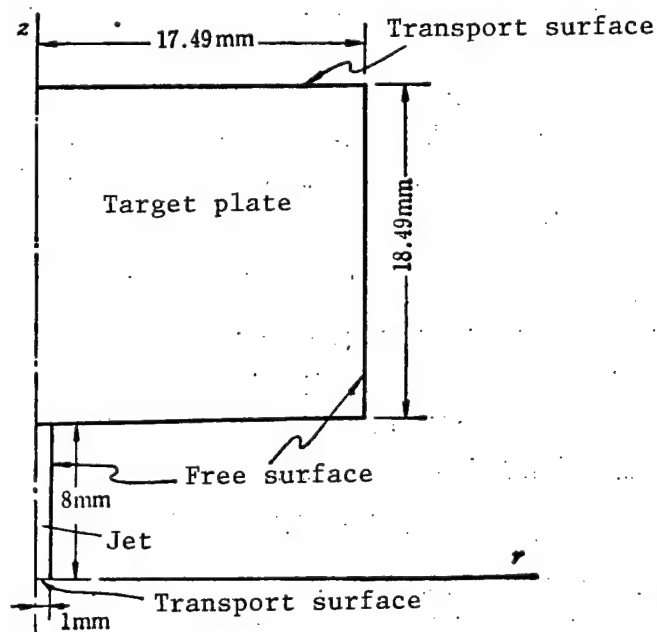


Figure A. Calculated Shape When  $t = 0$

<sup>\*</sup> When blockage occurs within the hole during penetration, the relationship  $V_j$ - $V$  is only appropriate before the blockage

The initial conditions are:

Steel target plate:

Density  $\rho_t^0 = 7.85 \times 10^3 \text{ kg/m}^3$

Pressure  $p = 1 \text{ atmosphere} = 10^5 \text{ Pa}$

Temperature  $T = 293\text{K}$

Specific internal energy  $I_t^0 = 0.6369426 \times 10 \text{ J/kg}$

Radial particle velocity  $u = 0$

Axial particle velocity  $v = 0$

Radius 17.49 mm

Thickness Semi-infinite (computed thickness 18.49 mm)

Copper jet flow:

Density  $\rho_j^0 = 8.60 \times 10^3 \text{ kg/m}^3$

Pressure  $p = 1 \text{ atmosphere} = 10^5 \text{ Pa}$

Temperature  $T = 1,073\text{K}$

Specific internal energy  $I_j^0 = 0.5843980 \times 10 \text{ J/kg}$

Radial particle velocity  $u = 0$

Axial particle velocity  $v_j^0 = 850 \text{ m/s}, 750 \text{ m/s}, 650 \text{ m/s}$  and  $601 \text{ m/s}$

Radius 1 mm

Length Semi-infinite (computed length 8 mm)

$I_t^0$  and  $I_j^0$  both were derived by substituting  $p = 1 \text{ atmosphere}$  and  $p = p_t^0, p_j^0$  into the Tillotson equation of state.

### III. Results of Calculations

#### 1. Steady penetration velocity

It was determined through four groups of calculations using different initial jet velocities  $V_j^0$  that the penetration velocity-time curve declines continually from a high velocity before  $2 \mu\text{s}$  and begins to fluctuate within a low velocity range after  $2 \mu\text{s}$ . The penetration velocity-time curve starts to become linear at  $2 \mu\text{s}$ . The hole bottom pressure-time curve also drops from a high pressure after  $2 \mu\text{s}$  to fluctuate within a low pressure range (Figures 1, 2 and 3). The jet can be considered to have entered steady penetration after  $2 \mu\text{s}$ . The Bernoulli formula for a steady non-compressible fluid can be used again to determine if the velocity and pressure at the plane of impact between the jet and the target plate conform to steady conditions:

$$\frac{1}{2} \rho_i (V_i - V)^2 = (p - s_{ss})_i + \frac{1}{2} \rho_i V^2$$

The  $(p-S_{zz})_t$  in the formula is the axial stress at the bottom of the penetration hole in the target plate. Table 1 lists the checks at  $V_j^0 = 850$  m/s:

Table 1

$t \mu s$	$V m/s$	$MPa$ $p^* = \frac{1}{2} \rho_j (V_j - V)^2$	$-S_{zz} = (p - S_{zz})_t$	$\frac{1}{2} \rho_j V^2$	$(p - S_{zz})_t + \frac{1}{2} \rho_j V^2$
2.05	$0.1253 \times 10^3$	$0.226 \times 10^4$	$0.7684 \times 10^3$	$0.0616 \times 10^3$	$0.8300 \times 10^3$
2.50	$0.1363 \times 10^3$	$0.219 \times 10^4$	$0.6979 \times 10^3$	$0.0729 \times 10^3$	$0.7708 \times 10^3$
2.60	$0.1450 \times 10^3$	$0.214 \times 10^4$	$0.2814 \times 10^4$	$0.0825 \times 10^3$	$0.2896 \times 10^4$
3.02	$0.1270 \times 10^3$	$0.224 \times 10^4$	$0.2802 \times 10^4$	$0.0633 \times 10^3$	$0.2865 \times 10^4$
3.55	$0.1547 \times 10^3$	$0.2088 \times 10^4$	$0.1875 \times 10^4$	$0.0939 \times 10^3$	$0.1969 \times 10^4$
4.02	$0.1677 \times 10^3$	$0.200 \times 10^4$	$0.3075 \times 10^4$	$0.1104 \times 10^4$	$0.3185 \times 10^4$
$\bar{V} = 0.1425 \times 10^3 m/s$		$p^* = 0.215 \times 10^4 MPa$		$0.2086 \times 10^4$	

Table 1 shows only a 3 percent error between  $p^*$  and  $(p - S_{zz})_t + \frac{1}{2} \rho_j V^2$

which indicates that the steady penetration stage has been entered. This method also was used to reorganize the calculated data to derive the steady penetration velocity  $V$  (Table 2). In Table 2,  $R/r$  is the ratio between the pitting diameter  $R$  and initial jet radius  $r$  when the steady condition begins (that is, when the pitting stage ends). Table 2 shows that the pitting radius is about one and one-half times the jet radius.  $\Delta Ty/r$  is the ratio between the depth of pitting and the initial jet radius, and is about 1.

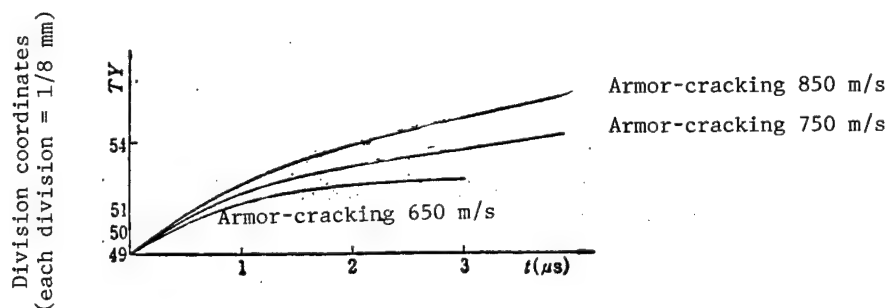


Figure 1

Table 2

$V_j^0 m/s$	850	750	650	601
$V m/s$	142	105	34.8	30
$R/r$	6.9/4	6.6/4	6.4/4	6.2/4
$\Delta Ty/r$	4.8/4	3.9/4	3/4	2.5/4

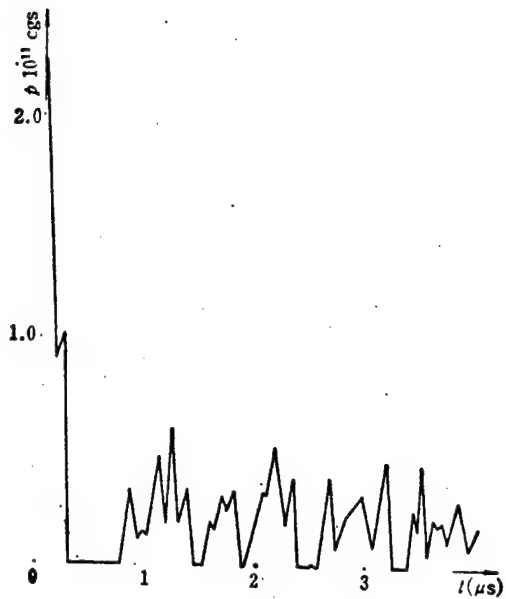


Figure 2. Armor-Cracking 750 m/s  
Cu  $\rightarrow$  Fe Hole Bottom Pressure Over Time

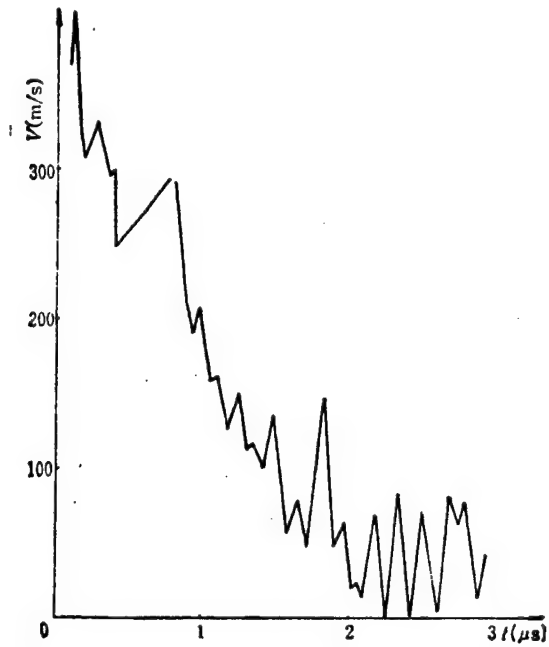


Figure 3. Armor-Cracking 650 m/s  
Hole Bottom Velocity Over Time

Figure 4 compares the relationship between the four groups of computed values of  $V_j$ -V and the  $V_j$ -V of an ideal non-compressible fluid.

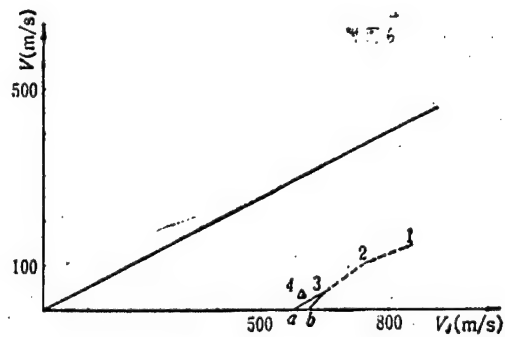


Figure 4

### 3. A set of calculations for changes in target plate strength

The strength of the target plates used in the computing program can be adjusted to calculate the penetration of a steel target plate by a copper projectile. When the ordinary temperature ordinary pressure dynamic load strength of the target plate is assumed to be  $2.30 \times 10^3$  Mpa and the velocity of the projectile is 900 m/s, the calculated penetration velocity hovers near zero.

### 3. Conversion of jet energy during the penetration process

Jet energy dissipation during the pitting stage (energy absorbed by the target plate).

The calculation results in Table 3 show that the energy dissipated during pitting rises as the jet velocity is increased. Figure 5 shows target plate energy changes with time and depth through the entire penetration process at  $V_j^0 = 750$  m/s. It is apparent in Figure 5 that the changes in target plate energy over time or penetration depth move from an initial non-steady stage toward stabilization into a steady stage. During the early period of impact, formation of a shock wave means energy dissipation is at a maximum as indicated by the very large slope at the beginning of the E-t curve and the E-Ty curve.

Table 3

$V_j^0$ m/s	Target plate total energy $J_0$	Energy absorbed by plate in pitting state $J$	Percentage of energy absorbed by target plate as a proportion of initial jet energy
850	0.888636	$0.117250 \times 10^2$	12.3%
750	0.888636	$0.862272 \times 10$	11.9%
650	0.888636	$0.609651 \times 10$	11.5%

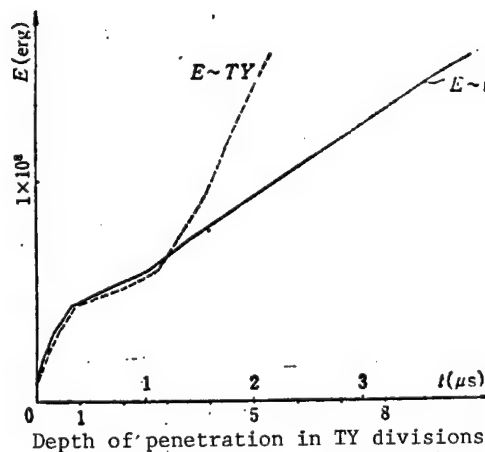


Figure 5. Armor-Cracking 750 m/s Target Plate E-t and E-Ty

Table 4 lists the results of the relevant calculations when  $V_j^0 = 650$  m/s.

Table 4

$\mu s$	Total target plate energy J	Hole bottom position in divisions(Ty)	$\mu s$	Total target plate energy J	Hole bottom position in divisions(Ty)
0	0.888636	49.00	2.17	0.698515 $\times 10$	52.08
0.08	0.181056 $\times 10$	49.21	2.26	0.734900 $\times 10$	52.11
0.16	0.255130 $\times 10$	49.43	2.43	0.756907 $\times 10$	52.17
0.32	0.338407 $\times 10$	49.54	2.67	0.790374 $\times 10$	52.24
0.67	0.395219 $\times 10$	50.59	2.94	0.849152 $\times 10$	52.37
1.37	0.547601 $\times 10$	51.65			

By organizing the three sets of computed data:

Table 5

$V_j^0$ m/s	Energy absorbed by target plate per unit of depth of penetration (J)	
	Pitting stage	Steady penetration stage
850	0.22087 $\times 10$	0.40917 $\times 10$
750	0.20215 $\times 10$	0.41875 $\times 10$
650	0.18012 $\times 10$	0.53172 $\times 10$

The data show that the energy dissipated per unit of depth in steady penetration is about double that of pitting, and that lower jet velocities increase the energy dissipated in steady penetration. Thus, the depth of penetration can be increased by increasing the velocity of the armor-cracking elastic jet microcomponents or sustaining the jet for a longer period of time.

#### IV. Analysis of Results

##### 1. Analysis of the four groups of $V_j$ -V data

(1) One can see in Figure 4 that point 4 ( $V_j = 601$  m/s,  $V = 30$  m/s) does not lie on the same curve as the three other points and that the slope between point 4 and point 3 does not conform to physical analysis, the slope being

$$\frac{dV}{dV_i} \approx \frac{\Delta V}{\Delta V_i} = \frac{4.8}{49} \approx 0.1$$

According to the Bernoulli formula for an ideal non-compressible fluid

$$\frac{1}{2} \rho_i (V_i - V)^2 = \frac{1}{2} \rho_i V^2,$$

the steady penetration velocity during penetration of a steel target plate by a copper jet is



$$V = 0.512 V_j \text{ or } \frac{dV}{dV_j} \approx \frac{1}{2}$$

If we use Zheng Shemin's formula for  $V_j$ - $V$

$$\frac{1}{2} \rho_i (V_j - V)^2 = \frac{1}{2} \rho_i V^2 + KY_0 \left[ 1 + \alpha \left( \frac{\frac{1}{2} \rho_i V^2}{Y_0} \right)^{\mu} \right]$$

then

$$\frac{dV}{dV_j} = \frac{1}{1 + \frac{\rho_i}{\rho_j} \frac{V}{V_j - V} + \frac{1}{2} K \cdot \alpha \cdot \mu \frac{\rho_i}{\rho_j} \frac{V}{V_j - V} \left( \frac{\frac{1}{2} \rho_i V^2}{Y_0} \right)^{\mu-1}}$$

Assuming that  $\mu = 1$  [2], when  $\alpha = 0$ ,  $\left. \frac{dV}{dV_j} \right|_{V=0} = 1$ ;  $\alpha \neq 0$ ,  $\frac{1}{2} < \left. \frac{dV}{dV_j} \right|_{V=0} < 1$

It is apparent from the changes in target plate strength with  $V$  that the slope of the  $V_j$ - $V$  curve in the high velocity stage is approximately 0.512 and approaches 1 where  $V = 0$ . The slope between point 4 and point 3, however, is only 0.1, which may indicate problems with the calculations for point 4 or that the computational error is rather large.

(2) It is assumed that the other three groups of data on  $V_j$ - $V$  can be used to determine the critical penetration velocity  $V_j^*$  of the target plate.

a) Applying the semi-empirical formula to determine  $V_j^*$  of the target plate.

Eichelberger provides a Bernoulli formula containing strength to describe the steady process of armor-cracking penetration:

$$\frac{1}{2} \rho_i (V_j - V)^2 = \frac{1}{2} \rho_i V^2 + R_t \quad (1)$$

In the  $R_t = KY_0$  in the formula,  $Y_0$  is the target plate dynamic strength under ordinary temperature and ordinary pressure, and  $K$  is the strength geometry

factor. When  $V = 0$ ,  $R_t = \frac{1}{2} \rho_i V_j^{*2}$ . When the three groups of  $(V_j, V)$  and  $Y_0 = 10^9$  Pa derived through calculation are substituted into formula (1),  $R_t$ ,  $K$  and  $V_j^*$  can be derived (Table 6).

Table 6

$V_j$ m/s	$V$ m/s	$\frac{1}{2} \rho_i (V_i - V)^2$ Pa	$\frac{1}{2} \rho_i V^2$ Pa	$R_i = \frac{1}{2} \rho_i V_i^2$ Pa	$K$	$V_j^*$ m/s
850	142	$0.216 \times 10^{10}$	$0.786 \times 10^8$	$0.208 \times 10^{10}$	2.08	695
750	105	$0.179 \times 10^{10}$	$0.432 \times 10^8$	$0.175 \times 10^{10}$	1.75	638
650	348	$0.1625 \times 10^{10}$	$0.475 \times 10^8$	$0.1620 \times 10^{10}$	1.62	613

Applying the semi-empirical formula of Zheng Zhemin for  $V_j$ - $V$ , the estimated  $V_j^* = 590$  m/s.

If we use the formula

$$\frac{1}{2} \rho_i (V_i - V)^2 = \frac{1}{2} \rho_i V^2 + KY_0 \left[ 1 + \alpha \left( \frac{\frac{1}{2} \rho_i V_i^2}{Y_0} \right)^{\mu/2} \right]$$

and assume that  $\mu = 1$  and  $\alpha = 0.1$  we can derive  $V_j^*$  (Table 7).

Table 7

$V_j$ m/s	$V$ m/s	$\frac{1}{2} \rho_i (V_i - V)^2$	$\frac{1}{2} \rho_i V^2$	$\frac{1}{2} \rho_i (V_i - V)^2 - \frac{1}{2} \rho_i V^2$	$\left( \frac{\frac{1}{2} \rho_i V_i^2}{Y_0} \right)^{1/2}$	$K$	$V_j^*$ m/s
850	142	$0.216 \times 10^{10}$	$0.786 \times 10^8$	$0.208 \times 10^{10}$	$\sqrt{3.11}=1.76$	1.76	640
750	105	$0.179 \times 10^{10}$	$0.432 \times 10^8$	$0.175 \times 10^{10}$	$\sqrt{2.42}=1.55$	1.51	592
650	34.8	$0.1625 \times 10^{10}$	$0.475 \times 10^8$	$0.162 \times 10^{10}$	$\sqrt{1.82}=1.35$	1.43	576

Note: The average  $V_j^* = 602$  m/s

In summary, when the results of numerical calculations are substituted into the semi-empirical formula, the derived range of critical penetration velocities for a steel target plate at ordinary temperature and ordinary pressure and a dynamic strength of  $Y_0 = 10^3$  MPa is 590 m/s to 649 m/s.

b) The three points at 1, 2 and 3 in the derived plot of  $V_j$ - $V$  can be used to extrapolate the point where  $V = 0$  (Figure 4).

If at point 3 we make  $\frac{dV}{dV_j} = \frac{1}{2}$  and let the two straight lines intersect  $V$ , at points a and b.  $V_j = 580$  m/s at point a and  $V_j = 612$  m/s at point b. The critical penetration velocity of the target plate is within the range of  $600 \pm 20$  m/s.

## 2. Checking the derived critical penetration velocity

### (1) Checking the changes in calculated target plate strength

Another set of calculations were made for the perpendicular penetration of the target plate by copper projectiles (round columns). The projectile velocity  $V_j^0 = 900$  m/s and the target plate strength was adjusted during the calculation process. When  $Y_0 = 2.30 \times 10^9$  Pa in the formula used to calcu-

late strength,  $Y = Y_0 \left(1 + \alpha \frac{p}{Y_0}\right)$ , the calculated critical penetration velocity is essentially zero.

Based on the law of analogues for armor-cracking penetration[6], no changes were made in any projectile or target plate parameters. Only the target plate strength parameter  $Y_0$  was changed, so the steady penetration velocity is

$$\frac{V}{V_i} = f\left(\frac{Y_0}{\frac{1}{2} \rho_i V_i^2}\right)$$

When  $V_j = V_j^*$ , then  $V = 0$ . If the non-dimensional variable  $\frac{Y_0}{\frac{1}{2} \rho_i V_i^2}$  is the same, then  $\frac{V}{V_j}$  also will be identical.  $Y_0$  represents the ordinary temperature and ordinary pressure target plate dynamic strength. We have already derived  $Y_0 = 2.30 \times 10^9$  Pa and  $V_j^* = 900$  m/s. Thus,  $V_j^*$  can be derived when  $Y_0 = 10^9$  Pa.

$$\frac{2.30 \times 10^9}{\frac{1}{2} \rho_i (0.9 \times 10^3)^2} = \frac{1 \times 10^9}{\frac{1}{2} \rho_i \cdot V_i^{*2}} \quad V_i^* = 600 \text{ m/s}$$

This result basically conforms to the armor-cracking calculations and indicates that they have a definite reliability. This means that the results of numerical calculations on two-dimensional non-steady fluid elastic-plasticity conform to the most fundamental physical principles of dimensional analysis.

### (2) Comparison with critical penetration experiments[7]

Reference (7) points out that by substituting the experimentally-measured depth of projectile target plate penetration and initial projectile impact velocity into the semi-empirical formula, the critical target plate penetration velocity can be calculated. The critical penetration velocity of 603# steel with a strength of ( $10^9$  Pa) is 912 m/s. In formula (1) the corresponding  $R_t = 3.64 \times 10^9$  Pa.  $R_t$  represents the resistance of the target plate hole bottom. It is already known that the maximum resistance to a spherical boring material in an infinitely elastic-plastic medium is  $p_s = 4.0 \times 10^9$  Pa, while the resistance to a cylindrical boring material is  $p_c = 3.40 \times 10^9$  Pa.

The experimentally-derived  $R_t$  falls between  $p_s$  and  $p_c$ , so it has a certain degree of reliability. For this reason, it is felt that the 600 m/s critical penetration velocity for 603# steel derived through two-dimensional calculations is too low, and that the error is about 30 to 40 percent.

More intensive work is needed concerning the reasons for the substantial error created using two-dimensional non-steady numerical calculation methods for low-velocity impact questions, but a preliminary analysis indicates that the causes may include the following:

- 1) At low velocity and low pressure, the state values of the materials are not suitably described using the Tillotson equation of state in existing programs.
- 2) Elastic power at low velocities and low pressures cannot be ignored, and elastic power was not deducted from the calculations in this program nor the contribution of exterior mechanical power toward internal energy.
- 3) Fluctuations occurred in the calculated data at low velocity and low pressure, which affected the accuracy of the numerical analysis.

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12539/7358

## EFFICIENT NARROW LINEWIDTH WAVEGUIDE DYE LASER PUMPED BY CuCl LASER

40080101a Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese  
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[Text] Abstract: This paper reports on an efficient narrow linewidth waveguide dye laser which is pumped by a CuCl laser. With this tunable dye laser, a conversion efficiency of 12.5 percent, linewidth of 4 Ghz, wide band ASE background of 4.7 percent, and a divergence angle of 3 mrad were obtained. The paper also provides a comparison of the output characteristics for some dye laser resonators.

## I. Introduction

Wave guide dye lasers have very high energy conversion efficiencies and output powers and many experimental and theoretical studies have been made of them.[1-2] This paper utilizes the characteristic of high efficiency in wave guide dye lasers combined with gratings, etalon, prism beam expansion systems and other tuning components to construct a wave guided dye laser with high efficiency and a narrow spectral line. We also did comparisons of the output characteristics with respect to Littrow grating cavities and grazing incidence grating cavities.

## II. Experimental Apparatus

Figures 1(a) and 1(b) respectively show the Littrow grating cavity and grazing incidence cavities for wave guide dye lasers. In (b), the grating grazing incidence angle is  $4^\circ$  and  $M_2$  is a totally reflective mirror. In (a),  $M_1$  is the output coupling mirror. In order to obtain optimum output coupling with different dissipations in the cavity, different reflectivities are selected (8%, 50%, 70%).  $L_1$ ,  $L_2$  are the lenses in the cavity with focal distances of 70 mm and 40 mm. E is the etalon with thickness of 4 mm or 5 mm. C is the dye box, L is a cylindrical lens with 100 mm focal distance, G is the grating with 1400 lines per mm. The total cavity length is 25 to 30 cm. The prism beam expander multiplier, M, is taken as 9 or 27.

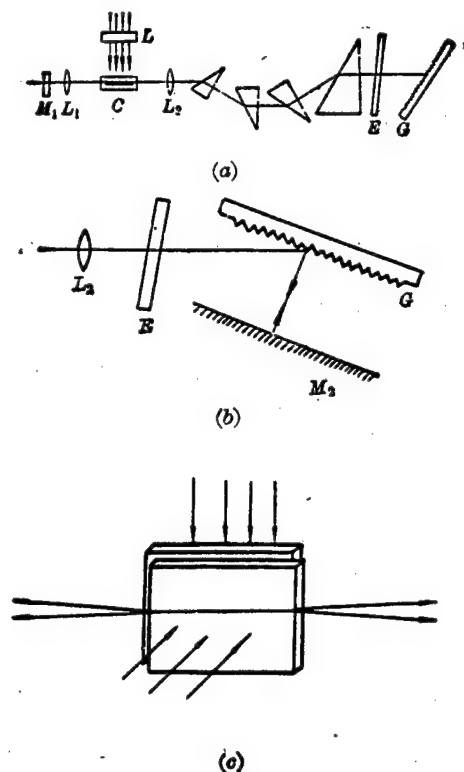


Fig. 1. Wave Guide Dye Laser Schematics

Figure 1(c) is the wave guide dye box schematic. The dye fluid film is 0.8 mm thick and 18 mm wide. The width of the pump focal line is about 0.1 mm, the dye velocity is about 0.5 m/s, and the dye concentration is  $2 \times 10^{-3}$  M.

A CuCl laser adopts an unstable cavity structure[4] in order to improve directionality. The divergence angle was 1 mrad, the maximum output power was about 1.2 W, the pulse width was 10 ns, the repetition rate was 11 kHz, and the wavelength was 510.6 nm.

The dye laser power was measured by a JG III type laser power meter while the power of the pumping laser was measured with an SD 2490 type laser power meter made by the Suzhou Vacuum Tube Factory.

### III. Observation of the Wave Guide Effect

In wave guide dye lasers, besides the "wave guide" effect produced by the dye box, there is also present a "self guiding" effect produced by a nonuniform distribution of the index of refraction in the dye solution.[5] Both of these effects are present simultaneously in wave guide dye lasers. In the experiments reported in this paper, the laser experiences "self guiding" restriction in the vertical direction and "wave guide" restriction in the horizontal direction. Using the experimental apparatus of Fig. 1(c), one can

observe ASE (amplified self excitation emission) light spots like those shown in Fig. 2 [not reproduced] From Fig. 2 we know that two bright spots appear in the vertical direction which illustrate the "self guiding" effect experienced in the vertical direction. In our experiments the "wave guide" effect is not obvious since the dye absorption depth is only 0.1 mm but when the pumping power is increased two bright spots will also appear in the horizontal axis.

#### IV. Output Characteristics of the Wave Guide Dye Laser

##### 1. Relationship of Output Power, Efficiency, and Pumping Power

Using the experimental apparatus in Fig. 1, with the output coupling mirror reflectivity at 8 percent and the etalon thickness at 4 mm, the change of output power and conversion efficiency according to pumping power was as shown in Figs. 3 and 4. Figure 3 corresponds to a Littrow grating cavity while Fig. 4 is for a glancing incidence grating cavity. From Fig. 3 we can see that the pumping power threshold is only 0.3 W. At a pumping power of 0.80 W, the maximum output power is 100 mW, the efficiency is 12.5 percent, and the corresponding line width is 4 GHz. If the 4 mm standard block is replaced with a 5 mm thick quartz standard block, then at a pumping power of 0.6 W, the efficiency falls from 11.5 to 9.0 percent, and the corresponding line width is compressed down to 1.0 GHz. From Figs. 3 and 4 we know that the efficiency of a grazing cavity incidence grating is less than a Littrow grating cavity.

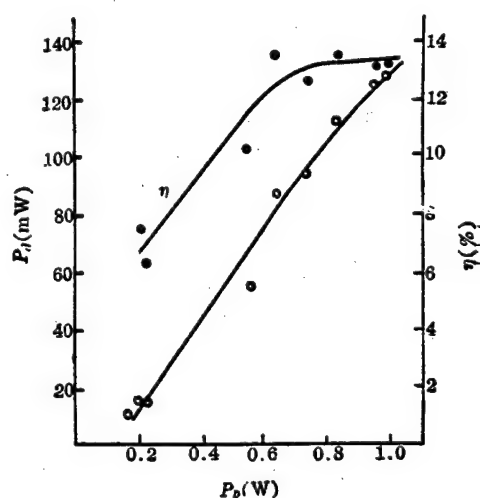


Fig. 3. Relationship of Output Power and Efficiency to Pumping Power in a Littrow Grating Cavity

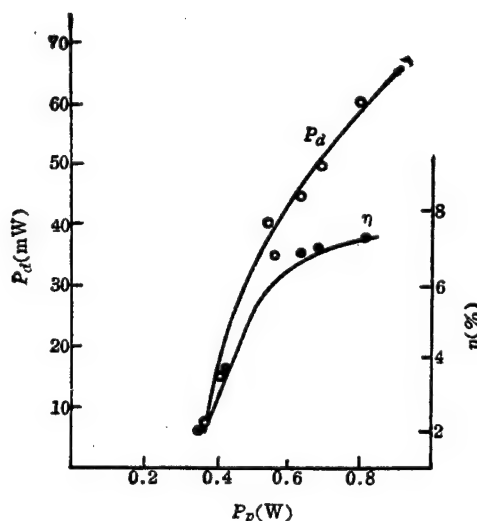
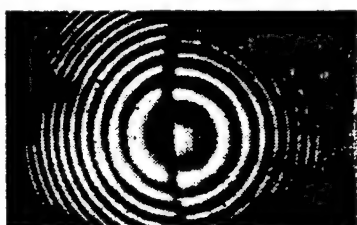


Fig. 4. Relationship of Output Power and Efficiency to Pumping Power in a Grazing Incidence Grating Cavity



## 2. Half Width of the Spectral Line

Using 10 mm or 20 mm thick quartz etalon we measured laser line widths. With a lens with a focal length of 1 m placed after the etalon a stripping lens camera was used to photograph interference rings in the plane of the lens as shown in Fig. 5. In order to eliminate measurement errors caused by base plate black levels and nonlinearity of light intensity, a lens plate with 50 percent transmissivity was introduced on the right side attenuating the light intensity to determine the base plate black level at half strength. Figure 5(a) and (b) are the laser interference when a 5 mm thick standard block was introduced and the prism beam expander multiplier was respectively 9 and 27. The measured line widths were respectively 1 GHz and 0.5 GHz. If the etalon was exchanged for one 4 mm thick, the line widths were 4 GHz and 2 GHz. In the experiments we discovered that when the line width was smaller than 500 MHz, frequency drift occurred but when the line width was larger than 1 GHz, the laser was tunable in a large range without mode jumping.



(a)

(a)  $M = 9$ , line width 1 GHz



(b)

(b)  $M = 27$ , line width 0.5GHz

Fig. 5. Dye Laser Interference

Employing the grazing incidence grating cavity of Fig. 1(b) and introducing a 4 mm thick standard block, when the grazing angle is  $4^\circ$  the line width can reach 5 GHz (the free spectrum of the etalon was measured to be 5 GHz).

## 3. Relationship of ASE Background and Output Mirror Reflectivity

In wave guide dye lasers, due to the action of the wave guide effect, laser gain is high and ASE rather strong. The presence of ASE facilitates adjusting of resonant cavities in several ways but influences laser power. For this reason in the experiments wide band ASE background was reduced as much as possible.

Adopting the optical path of Fig. 1(a), we used a monochromator to measure the intensity,  $I_{ASE}$ , at the wide band ASE central wavelength and the laser intensity,  $I_L$ . The ratio of these two quantities can reflect the relationship between wide band ASE and output mirror reflectivity. The results of such an examination is given in Fig. 6.

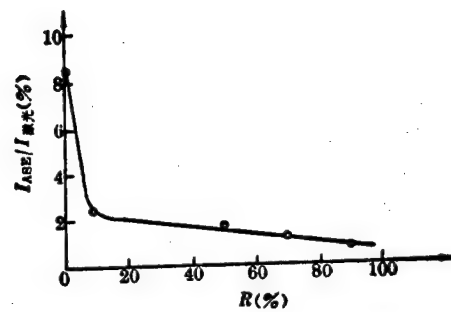


Fig. 6. Relationship of ASE background and output mirror reflectivity

The experiments revealed that the ASE background is non polarized light. Therefore, in addition to using a high reflectivity output mirror, the ASE background can be lowered by inserting a polarized plate in the cavity.

#### 4. Tuning Range

We used an HRS-2 model grating monochromator to measure the tuning range and the relative values of the intensity at the various wavelengths with results as shown in Fig. 7. The tuning range was 570 to 612 nm.

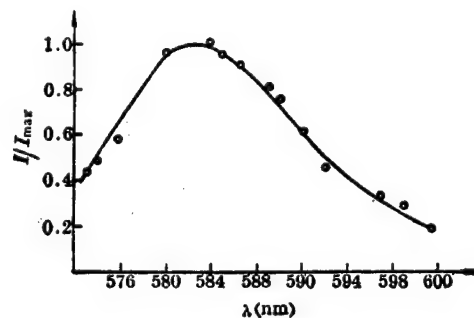


Fig. 7. Tuning Curve

#### 5. Comparison of Littrow grating cavity and grazing incidence cavity

Study was done on the output characteristics of a Littrow grating cavity and a grazing incidence cavity. The results of this study are arranged in Table 1 from which we derive the following points concerning a comparison of the two output characteristics:

- (a) At the same pumping power, the efficiency is higher for a Littrow grating cavity than a grazing incidence grating cavity;
- (b) The tunable width of a Littrow grating cavity is wider than for a grazing incidence grating cavity.

In our experiments, we received the assistance of Shi Gongming [2457 7895], Song Xiudong [1345 4423 0392], and Wang Ping [3769 1627] to whom we express our gratitude.

Table 1. Output Characteristics of Wave Guide Dye Laser Gratings

	Littrow Grating Cavity		Grazing Incidence Cavity
pump power (W)	0.6	0.6	0.6
pulse repetition rate (kHz)	11	11	11
pump pulse width (ns)	10	10	10
dye optical width (ns)	5	5	5
dye optical power (mW)	69	54	42
conversion efficiency (%)	11.5	9	7
prism beam expander multiple	9	27	n/a
width of standard block (mm)	4	4	4
line width (nm)	$4.2 \times 10^{-3}$	$2.6 \times 10^{-3}$	$5.7 \times 10^{-3}$
narrow band ASE back-ground $\frac{I_{\omega}}{I_{\text{laser}}}$	2.5%		4%
wide band ASE background	4.7%	6%	
tunable range (nm)	570~612	570~612	574~600

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12966/7358

SEPARATION OF DEUTERIUM AND HYDROGEN BY INFRARED MULTIPHOTON DISSOCIATION IN TRIFLUOROACETAL DEHEDYDE

40080101b Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 14, No 2, 20 Jul 87 pp 428-430

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[Text] Abstract: We used the 9.6  $\mu\text{m}$  P(26) infrared line of a TEA  $\text{CO}_2$  laser to dissociate trifluoroacetal dehydride, separating deuterium from hydrogen. In photolysis of gaseous  $\text{CF}_3\text{CHO}$ , when the quantity of trifluoroacetal dehydride ( $\text{CF}_3\text{CDO}$ ) in the reactant was 2.4 percent, the separation coefficient reached 200 and the deuterium content in the reactant was 80 percent. The addition of helium would increase the separation effect but the presence of oxygen would induce a chain reaction and selectivity would be lost.

## I. Introduction

The use of molecularly selective infrared multiphoton dissociation effects to separate isotopes, particularly the separation of light isotopes, is recognized as an effective procedure. For example in the trifluoromethane series, through infrared multiphoton dissociation of trifluoromethane in natural abundancies, the separation coefficient of deuterium and hydrogen has surpassed  $2 \times 10^4$ . [1] Due to the rather large isotope displacement present near the oscillation spectrum of trifluoroacetal dehydride and trifluoroacetal at 9.68  $\mu\text{m}$ , [2] research has already been done on this infrared multiphoton dissociation mechanism. [3] We used a TEA  $\text{CO}_2$  laser to selectively dissociate trifluoroacetal dehydride. When the hydrogen to deuterium ratio was 100:2.4, the component of deuterium in the dissociation reactant reached 80 percent and higher, thus obtaining a quite good separation effect.

## II. Experimental Method

The trifluoroacetal sample for our experiment was prepared according to the method of M. Braid. [4] The chromatic analysis results of our sample showed the  $\text{CF}_3\text{CHO}$  to be greater than 98 percent pure. The trifluoroacetal dehydride was a hydrate obtained using aluminum lithium hydride dehydride reduced at

-5°C to trifluoroacetal and after dehydrolysis in phosphoric anhydride at 90°C, passed through multiple vacuum rectifications. No abnormal peaks turned up on the mass spectra and infrared spectra analysis results for the sample.

The laser device was the same as that described in reference [3]. The TEA CO<sub>2</sub> laser pulse half width was 100 ns, the converging lens was a 45 cm single concave lens, and the diameter of the light spot at the center of the focal point was 0.9 mm. The reactor was a 26 x 170 mm cylindrical glass reaction pool with sodium chloride windows at each end. The charge pressure error was not greater than ±0.02 Torr.

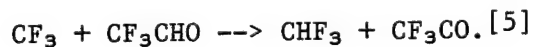
After the product was condensed using liquid air, it was sent for analysis to a JGC-20K-JMS-D300 chromo-mass joint meter. The uncondensed sample was analyzed qualitatively in an Specord 75 infrared spectrometer. The low boiling point constituents not condensed by the liquid air were analyzed directly in sample by a mass spectrometer. The hydrogen to deuterium ratio of the trifluoroacetal dehydride before and after the reaction was determined using a JMS-D300 mass spectrometer.

### III. Results and Discussion

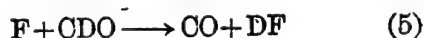
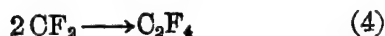
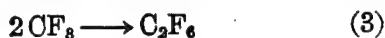
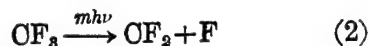
#### 1. Dissociation Product and Multiple Photon Mechanism

We used a focused 10.6 μm P(8) line pulse CO<sub>2</sub> laser to irradiate trifluoroacetal. When the laser energy was 0.05 to 0.5 J and the pressure of the trifluoroacetal in the reaction pool was 0.02 to 2 Torr, the analysis of the dissociation product's chromatic, mass, and infrared spectra demonstrated that the principle products of trifluoroacetal infrared multiple photon dissociation were: C<sub>2</sub>F<sub>6</sub>, C<sub>2</sub>F<sub>4</sub>, CO, with minute quantities of CH<sub>2</sub> = CF<sub>2</sub>, CF<sub>3</sub>-CF<sub>2</sub>-CF<sub>3</sub>, CF<sub>3</sub>-CHF<sub>2</sub>, H<sub>2</sub>. In the process of the experiment, after passing through multiple cycles, obvious signs of haze could be seen on the surface in the glass reaction pool caused by HF corrosion. Consequently the major products containing hydrogen and deuterium were HF and DF.

When pure trifluoroacetal dehydride undergoes infrared multiphoton dissociation under 9.6 μm P(26) line pulse CO<sub>2</sub> laser illumination, the chromatic spectra curve of the dissociation product is nearly identical to the chromatic spectra curve of trifluoroacetal infrared multiphoton dissociation product. The major mass spectra segments are also completely the same, that is the dissociation product is mostly C<sub>2</sub>F<sub>6</sub>, C<sub>2</sub>F<sub>4</sub>, and CO. When a gaseous mix of 1:1.2 parts trifluoroacetal and trifluoroacetal dehydride is illuminated by a 9.6 μm P(26) pulse CO<sub>2</sub> laser, the characteristic absorption peak of trifluoroacetal located at 2150 cm<sup>-1</sup> fall off but there is no decrease in the characteristic absorption peak of trifluoroacetal at 2864 cm<sup>-1</sup>. Evidently, in the reaction process there is present no chain initiation reaction of CF<sub>3</sub> free base and CF<sub>3</sub>CHO or CF<sub>3</sub>CDO



In addition, the relationship between the optical dissociation pulse number and the dissociation rate also demonstrates the characteristics of a first order reaction. Consequently, at low pressure, for the possible major reactions of trifluoroacetaldehyde infrared multiphoton dissociation there are:



## 2. Deuterium-Hydrogen separation effect.

Between the 9.6  $\mu\text{m}$  band P(26) line and the 10.6  $\mu\text{m}$  P(6) line of a  $\text{CO}_2$  laser, there exists isotope displacement of about 70  $\text{cm}^{-1}$  between the  $\nu_3$  oscillation band of  $\text{CF}_3\text{CDO}$  and the  $\nu_{12}$  oscillation band of  $\text{CF}_3\text{CHO}$ . Moreover, the vibrator strength of the  $\text{CF}_3\text{CDO}$   $\nu_3$  mode is 4 or more times the vibrator strength of the  $\text{CF}_3\text{CDO}$   $\nu_{12}$  oscillation mode. According to the results of reference [2], the energy state density at the lower energy states of trifluoroacetal is very large and there is no obvious "red shift" in the relationship between the central frequency of multiple photon dissociation and the dissociation rate. The result of dehydride will make the energy state density even more compressed for the lower energy states of trifluoroacetal dehydride. As a consequence this makes the laser frequency strictly resonant with the molecular oscillation frequency. The above conditions are beneficial to the process of separation of hydrogen and deuterium through infrared multiphoton dissociation of trifluoroacetal dehydride. Figure 1(a) is a partial infrared spectrum of a sample where the ratio of trifluoroacetal to trifluoroacetal dehydride was 1:1.2 and the composite pressure was 2.2 Torr. After going through 500 laser pulse optical dissociations with 9.6  $\mu\text{m}$  P(26) ( $1041.28\text{ cm}^{-1}$ ) line at 0.2 J, the  $\nu_1$  absorption peak of trifluoroacetal dehydride at  $2150\text{ cm}^{-1}$  had clearly fallen while the decreased amplitude of the trifluoroacetal absorption peak at  $2864\text{ cm}^{-1}$  was not large. Table 1 summarizes the experimental results of separating hydrogen and deuterium through infrared multiphoton dissociation of trifluoroacetal dehydride. The definition of the separation factor,  $\beta$ , in Table 1 is

$$\beta = \frac{[\text{DF}/\text{HF}] \text{ during } \mu \text{ production}}{[\text{CF}_3\text{CDO}/\text{CF}_3\text{CHO}] \text{ before reaction}}$$

$$= \frac{\text{separation rate of trifluoroacetal dehydride}}{\text{separation rate of trifluoroacetal}}$$

Because the hydrogen fluoride in the dissociation product is not easily collected and directly analyzed, the separation factor in Table 1 is obtained through computations of measured trifluoroacetal and trifluoroacetal dehydride dissociation rates. The late item in Table 1 is also computed.

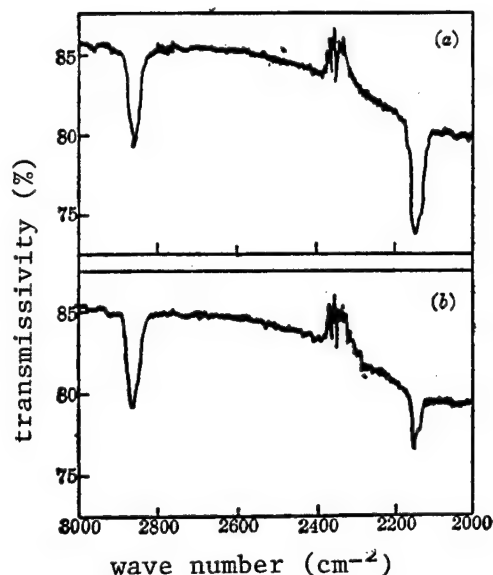


Fig. 1. Partial Infrared Spectrum Changes of Trifluoroacetal before and after Optical Dissociation. (a) before reaction (b) after reaction

A large amount of helium introduced into the reaction system would increase the separation coefficient. However, in the reaction and gas combination [6792 3049] processes, it will certainly prevent oxygen from leaking into the reaction pool and this is a key condition which influences the separation efficiency. The result of oxygen participation in the reaction will generate changes in the dissociation product and the reaction mechanism, producing  $\text{CF}_3\text{O}$ ,  $\text{CF}_4\text{O}$ , and  $\text{C}_3\text{F}_6\text{O}_2$ , and in particular will induce a trifluoroacetal chain reaction destroying isotope selectivity.[6]

From the results of our experiments it seems that infrared multiphoton dissociation of trifluoroacetal dehydride can give a rather good hydrogen-deuterium separation result. However, under ordinary conditions there is no isotope conversion reaction between hydrogen and heavy water in trifluoroacetal. Consequently, for hydrogen-deuterium conversion reaction under mixed conditions more research is needed in the area of conditional experiments on multiphoton dissociation.

Table 1. Experimental Results of Hydrogen-Deuterium Separation through Infrared Multiphoton Dissociation

Composite pressure (Torr)	Dehedyde sample con- tent in gas mixer before reaction (%)	Laser energy	Number of pulses	Dissociation rate of trifluoroacetal (%)	Dissociation rate of trifluoroacetal dehedyde (%)	Separation factor ( $\beta$ )	Content of deuterium fluoride in hydrogen fluoride (%)
2.2	54.5	0.23	500	8	44	5.5	87
1.06	2.4	0.23	500	0.45	34	79	64
1.04	3.5	0.22	500	0.63	31	50	64
1.58 (100 TorrHe)	2.4	0.17	1000	0.29	58	200	86

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12966/7358



EXPERIMENTAL RESEARCH ON SKIN REFLECTION, TRANSMISSION, ABSORPTION OF LIGHT RAYS

40080101c Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese  
Vol 14, No 2, 20 Jul 87 pp 440-443; 435

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of the Department of Physics, Third Military Medical College, Chongqing.  
Received 7 Dec 85; revised version received 13 Oct 86]

I. Introduction

Skin is the gateway to the human body. Covering its entire surface, optical and laser treatments must first penetrate the skin to reach the tissues and organs which lay beneath. For protection against laser light (excluding the eyes), it is the skin which bears the brunt. Obviously, study on the rules of reflectivity, transmissivity, and absorption of light by skin is an important item of basic research. This work will provide critical parameters for the study of the biological effects, doses, and protection threshold of light.

We used common light to carry out experiments, in the laser area using only a 2.7 mW He-Ne laser. Comparisons were also done between laser light and common light with a wavelength of 632.8 nm.

As everyone knows, there is a relationship between the biological effect and the optical energy absorbed by a living body, i.e. the absorbability. In general:

$$\text{absorbability} = 1 - \text{reflectivity} - \text{transmissivity}$$

Consequently, the key to our experiments was how to measure accurately the reflectivity and transmissivity so as to compute the absorbability. We know that the reflected light from a light ray incident on skin is diffuse reflection so that only by complete collection and recording of the entire energy of diffuse reflection are we able to measure accurately the skin's reflectivity. For this reason, we used an "integration sphere" to carry out these measurements.

## II. Experimental Apparatus

Our experiments were carried out on a UV-210A type double beam spectrometer equipped with a "integration sphere." The light source was a 50 W tungsten halogen lamp. Our experimental apparatus was as shown in Figure 1, in which R is the reference beam. Via the totally reflective mirror,  $M_3$ , and window, I, this beam enters the integration sphere (on which a uniform white oxidized magnesia mixture was spread all round) illuminating an oxidized magnesium white plate tightly adhered to the integration sphere at window II. The multiple reflections of this diffusely reflected beam uniformly illuminate the inner walls of the integration sphere. At the bottom of the integration sphere there is a 60 mm pore to which a photoelectric multiplier tube, P, is attached. A separate sample beam, S, illuminates a place at window IV after entering the integration sphere via the two totally reflective mirrors,  $M_1$  and  $M_2$ , through window III. If to window IV we affix an oxidized magnesium "standard white board," then a portion of the diffusely reflected light from it will enter the photo electric multiplier tube through the integration sphere. At this time the reflectivity read by the instrument for the standard white board is 100 percent. If a black body (specially made rough black suede) is placed at window IV, the instrument reads a reflectivity of 0. If any test material (like skin) replaces window IV, then we can measure its reflectivity. To measure the transmissivity we have window I wide open, seal up windows II and IV with oxidized magnesium white boards, and evenly stretch skin over window III. The instrument's scan range is 400 to 800 nm with a wavelength precision of  $\pm 2$  nm.

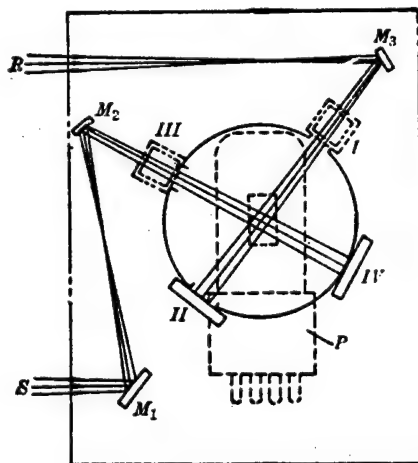


Fig. 1. Integration Sphere

## III. Experiment Results

1. Reflectivity and transmissivity curves for free human skin. The specimen was skin from over the tricep of the right upper arm, preserved at  $4^{\circ}\text{C}$  and tested 17 hours after removing subcutaneous fat. Our experiment results were as shown in Figure 2. The reflectivity and transmissivity both increased

with wavelength. Thus with increasing wavelength the absorbability got smaller. What is of note here is the absorption coefficient  $\mu$ , generally given by the formula  $I = I_0(1 - R)e^{-\mu x}$  (1). Therefore,

$$\mu = \frac{-1}{x} \ln \frac{I}{I_0(1-R)},$$

in which  $x$  is the thickness of the skin. Here  $x = 1.14$  mm,  $I/I_0$  is the transmissivity, and  $R$  is the reflectivity. The computational results for the absorption coefficient are shown in Table 1. From 400 to 800 nm, the value of  $\mu$  decreases with an overall difference of about 20 times.

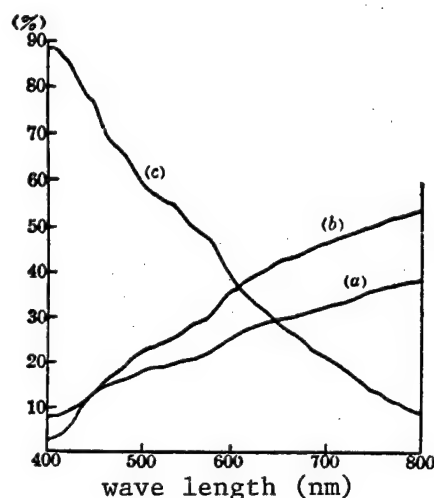


Fig. 2. Skin Reflectivity, Transmissivity, and Absorption Curves  
(a) Reflectivity, (b) Transmissivity, (c) Absorption

Table 1. Absorption Coefficient of Skin with Respect to Light

wavelength (nm)	corresponding laser	reflectivity %	transmissivity %	$\mu$ (mm <sup>-1</sup> )
400		8.0	4.0	2.750
441.6	He-Cd	12.0	11.0	1.824
488	Ar+	17.0	20.0	1.248
514.5	Ar+	19.0	24.0	1.067
632.8	He-Ne	28.5	40.5	0.499
694.3	Ruby	32.0	46.0	0.343
800		38.0	53.0	0.138

2. Reflectivity and transmissivity curves of a living finger. The specimen was the last segment of the middle digit on the right hand and the last segment of the index finger of the left hand of the authors of this paper (a middle aged woman and a middle aged man respectively). During the experiment, the inner side of the specimen was made to receive the sample beam. The resulting curves are shown in Figure 3. Comparing the reflectivity curves for the female and male fingers (a) and (b) and the transmissivity curve for a blood solution we made (c), the variational tendencies of the three are amazingly similar. Moreover the three have identical absorption peaks at 415, 524, and 578 nm. Due to the larger absorbability of fingers with respect to violet light (400 to 430 nm), the fingers' absorption peak at 415 nm is only dimly visible while the obvious peaks occur at 542 and 578 nm. The transmissivity of the fingers in the 400 to 800 nm wavelength range was zero.

3. Reflectivity and transmissivity curves of skin plus subcutaneous tissues. The specimen was skin plus subcutaneous tissues of the outside lower quadriceps from a young woman, preserved at 4°C and tested 15 hours after amputation. The experiment curves are shown in Figure 4. The reflectivity of the specimen increased with the thickness of the specimen. When the thickness was 7.12 mm, the transmissivity was 0 so reflectivity curve (a) is the highest reflectivity curve. There was no further increase with greater specimen thickness.

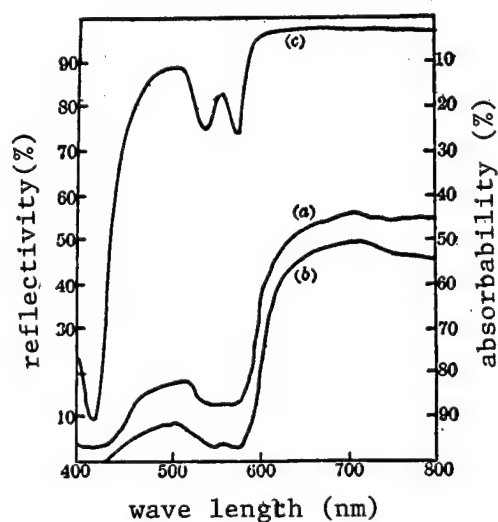


Fig. 3. (a) Reflectivity Curve for a Female Finger; (b) Reflectivity Curve for a Male Finger; (c) Transmissivity Curve for a Blood Solution

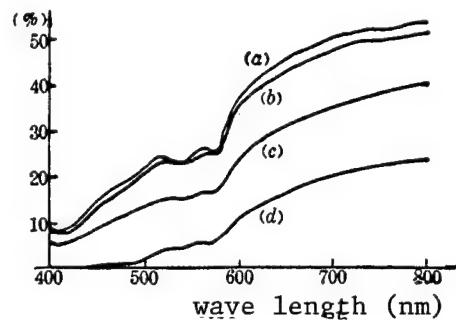


Fig. 4. Reflectivity and Transmissivity Curves for Skin Plus Subcutaneous Tissues from outside lower Quadriceps.

(a) Reflectivity Curve for thickness of 7.12 mm; (b) Reflectivity Curve for thickness of 4.62 mm; (c) Reflectivity Curve for thickness of 2.34 mm; (d) Transmissivity Curve for thickness of 2.07 mm.

4. Reflectivity and transmissivity curves of skin plus subcutaneous tissues. The specimen was dayuji [1129 7625 7139] from the left hand preserved at 4°C and tested 14 hours after surgery. The test results are given in Figure 5.

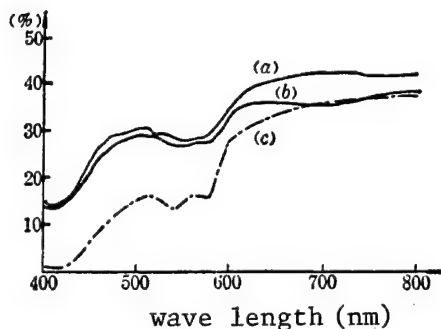


Fig. 5. Reflectivity and Transmissivity Curves for Skin plus Subcutaneous Tissues from dayuji

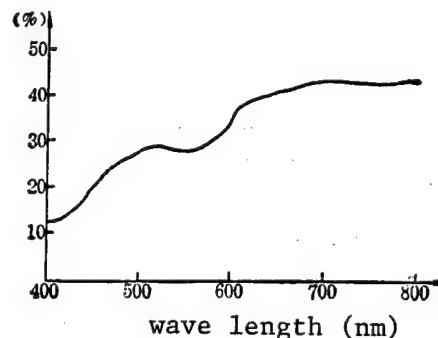


Fig. 6. Reflectivity of Water Washed Thumb

5. Reflectivity and transmissivity curves of a water washed digit. The specimen was the last joint of a thumb, preserved at 4°C, and tested 14 hours after amputation and a water wash extruded the blood out of the digit. (The palm side received the sample beam). The test results are as shown in Figure 6. In the 400 to 800 nm range the transmissivity of the specimen was zero.

6. Comparative test results for reflectivity and transmissivity under a 2.7 mW He-Ne laser and under an ordinary light with a wavelength of 632.8 nm (source: a 50 W halogen lamp) are arranged in Table 2.

Table 2

Light source	Specimen	Thickness (mm)	Reflectivity (%)	Transmissivity (%)
He-Ne laser	skin + sub- cutaneous tissue	2.32	32.2	12.8
ordinary light (632.8 nm)	as above	as above	30.3	12.8
He-Ne laser	muscle	2.42	28.1	5.5
ordinary light (632.8 nm)	as above	as above	26.9	6.0

### Experiment Analysis

From the above tests, we obtained four major conclusions.

1. When light impinges on the human body, reflection occurs not only at the skin surface but also in the layers inside the skin and in the various subcutaneous tissues. That the reflectivity curves of single layer skin (epidermis and derma) in Figure 2 are entirely different from the reflectivity curves of skin plus subcutaneous tissues in Figures 3 to 6 demonstrates that reflection occurs not only at the outer surface of the skin but is also related to subcutaneous tissues. In Figure 4 and Figure 5, as the thickness of skin plus subcutaneous increases, its reflectivity curve also increases, illustrating that with thicker tissues and more layers, the number of reflections increases so the total reflectivity also increases.

2. As light penetrates the various subcutaneous tissues from the skin, if it collides with blood, then the reflectivity and transmissivity curves exhibit absorption peaks identical to blood. However, if the light does not reach the blood then these blood absorption peaks do not appear. Like the living digit of Figure 3, where the subcutaneous blood vessels were well provided, there appeared at 415, 542, and 578 nm absorption peaks identical to those of blood. Also in the cases of Figure 4 and Figure 5 with blood in the subcutaneous tissue their reflectivity and transmissivity curves both showed absorption peaks identical to those of blood. And again, in Figure 6, as soon as the subcutaneous blood was washed out, the reflectivity curves no longer exhibited absorption peaks like those of blood.

3. When skin or human bodies are illuminated, the variation tendencies in reflectivity and transmissivity are respectively the same. As in Figure 2, both the reflectivity and transmissivity of the single layer skin increased with increasing wavelength while in Figure 3, Figure 4, and Figure 5, even though the skin plus subcutaneous tissues belonged to different parts of different people, the variation tendencies were overall the same.

4. Previous research on the reflection, transmissivity, and absorbability of light and lasers with respect to living tissue all sought to find the reflectivity, transmissivity, absorbability, and the absorption coefficient for a certain tissue layer. There is no doubt that such work is important; however, our experiments demonstrate that reflectivity is different according to tissue thickness. Consequently, the above research method conceals a mistaken point of view in believing that the reflection of light by living tissues is determined only by the surface.

## V. Application

When treatment is carried out using 400 to 800 nm light to illuminate the human body, the absorbability with respect to light is equal to 1 - reflectivity since the bulk of the body is not transparent to light. The reflectivity at this place should be a maximum reflectivity rather than the reflectivity of a single layer of skin. Since the maximum reflectivity is different according to person and position and the conditions are complex, on the surface, there seems to be no regularities which can be followed. However, as we recounted above, in Figures 3, 4, and 5, despite coming from different people and different locations, the variational tendencies in the reflectivity and transmissivity of skin plus subcutaneous tissues were largely the same. Therefore we believe that when light illuminates the human body, more or less there are the following regularities: (1) Between 400 and 800 nm, the variational tendencies of the maximum reflectivity curve are fundamentally the same; (2) Since all body skin has blood vessels beneath it, in the 400 to 800 nm range the maximum reflectivity curve has the same absorption peaks as for blood; (3) The reflectivity of the human body is lowest and its absorption highest with respect to violet light. Reflectivity is highest and absorption lowest with respect to red (630 to 750 nm) and near infrared (750 to 800 nm) light. The absorption of the violet varies between 2.5 and 10 times that of the red.

In comparison with experiments done by foreigners, (2,3) the maximum reflectivity of Asians between 400 and 800 nm is lower than for whites and higher than for blacks.

Some researchers (2,3) believe that the reflectivity and transmissivity of laser is equivalent to ordinary light with respect to living bodies. This theory, however, has not yet been verified experimentally. Table 2 from our experiments demonstrates that in the case of a few milliwatt laser, considering that its "nonlinear effect" can be ignored, its reflectivity and transmissivity can be seen as largely equivalent with ordinary light. Consequently, the research of this study provides some data on the biological effects of light and milliwatt lasers for treatment and protection.

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12966/7358



EFFECT OF ELECTRON BEAM DIVERGENCE ON FREE-ELECTRON LASER OUTPUT

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 14 No 7,  
20 Jun 87 pp 390-392

[Article by Lei Shizhan [7191 0099 3277] and Zhao Donghuan [6392 2639 3562] of  
Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Abstract] As reported here, an investigation showed that when the divergence of a relativistic electron beam entering a wiggler field increases, the gain of a free-electron laser will decrease. A small divergent angle will increase output power. The maximum allowable divergent angle is determined by the laser oscillation regime. A total of 37 equations express the basic principle, line width increment and the effect of the divergent angle on laser output characteristics. The paper was received for publication on 29 May 1986.

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- [3] He Guangsheng [6378 0342 3932] and Lei Shizhan, "Jiguangqi Sheji Jichu" ["Fundamentals of Laser Design"], 1979, Shanghai Science and Technology Publishing House.

10424

CSO: 4009/78

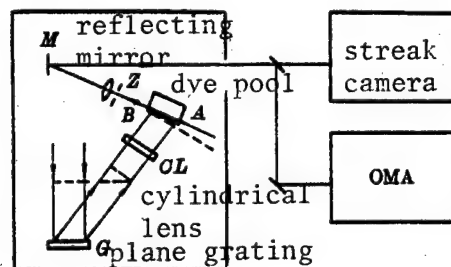
## INVESTIGATION OF ULTRASHORT TRAVELING-WAVE AMPLIFIED SPONTANEOUS EMISSION

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 14 No 7,  
20 Jun 87 pp 393-398

[Article by Li Wenchong [2621 2429 0394], Ning Changlong [3942 7022 7893],  
Huang Zuozhu [7806 0155 2691], Chen Jian [7115 0256] and Wang Wanlun [3769  
8001 0243] of the Department of Physics, Zhongshan University, Guangzhou]

[Abstract] Ultrashort traveling-wave amplified spontaneous emission (ASE) light pulses are generated by a transversal synchronized pumping arrangement with gradient distribution of pumping energy. Light pulses (50 picoseconds [ps]) were generated by nitrogen laser pumping, and 8 to 15 ps light pulses were generated by frequency doubled and mode-locked Nd:YAG laser pumping. The pulse shape and spectrum of traveling-wave and non-traveling-wave ASE were measured with a streak camera and an optical multicahnnel analyzer. Computer simulation of the temporal behavior of the traveling-wave ASE is presented, and the calculation is in good agreement with the experimental results.

The experimental arrangement is shown in the following figure:



Eight other figures show the waveforms and spectra of traveling-wave and non-traveling-wave ASE, output waveforms of traveling-wave ASE at different excitation zone lengths, dye energy level, small-signal increment coefficient, waveforms of pumping light pulse and spontaneous fluorescence signal light, traveling-wave ASE pulse duration and a cross section of pumping light over a dye pool. Three tables list experimental results, parameters used in calculations and effects on traveling-wave ASE pulse width by varying the excitation zone length and dye concentration. The paper was received for publication on 2 May 1986.

10424

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OBSERVATION OF SYNCHRONOUSLY TRANSIENT PUMPED MODE-LOCKING DYE LASER UNDER  
NEGATIVE CAVITY DETUNING

40090033 Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese  
Vol 14 No 10, 20 Oct 87 pp 583-585

[English abstract of article by Luo Ningyi [5012 1337 0001], et al., of the  
Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences,  
Shanghai; Wu Hongxing [0702 7703 5281] of the Department of Physics,  
University of Science and Technology of China, Hefei]

[Text] The second-harmonic pulse train from an actively/passively mode-  
locked Nd:YAG laser is used as the pumping source, and the negative cavity  
detuning effect of synchronously transient pumped mode-locking of a rhodamine  
6G dye laser with only 12 modulations is studied. It is found that under  
negative cavity detuning the laser pulse as a two-spike structure. The sub-  
spike disappears and the single pulse appears with the matched cavity length.  
(Received 29 May 86.)

9717

DISCUSSION OF TWO-MODE TWO-PHOTON CW LASER OSCILLATION

40090033 Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese  
Vol 14 No 10, 20 Oct 87 pp 589-593

[English abstract of article by Sun Songgeng [1327 2646 1649] of the Institute  
of Nanjing Communication Engineering, Nanjing]

[Text] The nondegenerate two-photon CW laser oscillation process using the stationary state solution of the reduced optical Bloch equation is discussed. The formulas for gain, saturation, dispersion and frequency pulling of the laser material are obtained. The results are compared with those of the mono-mode two-photon lasers. The effects of coupling between the two modes on the characteristics are analyzed. (Received 28 May 86.)

9717

QUANTUM BEATS IN SUPERRADIANCE

40090033 Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese  
Vol 14 No 10, 20 Oct 87 pp 594-598

[English abstract of article by Gu Qiao [7357 2884] of the Department of  
Physics, Northwest University, Xi'an]

[Text] A quantum theory for collective spontaneous emission of a multiatomic system with different resonance frequencies is applied here to the superradiant emission of two groups of atoms undergoing two independent transitions. An analytical expression for the emitted intensity as a function of time is obtained after making a rotating wave approximation, slowly varying envelope approximation and decorrelation approximation. (Received 16 Jun 86.)

9717

AUTO-ORIENTATION OF KDP CRYSTALS IN LASER FREQUENCY DOUBLING

40090033 Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese  
Vol 14 No 10, 20 Oct 87 pp 603-606

[English abstract of article by Wang Wenming [3769 2429 2494] of Wuhan Technical University of Surveying and Mapping; Yi Zhang [2496 2874], et al., of the Institute of Optics and Electronics, Chinese Academy of Sciences, Chengdu]

[Text] This paper puts forward a proposal for auto-orientation of a KDP crystal array and describes a microprocessor auto-orientation system which can auto-regulate the single piece of KDP crystal to its optimal matching direction. The control accuracy of the system is  $E = \pm 16.3$  s. The system is able to track the change of the matching angle in real time. It is also able to compensate for the influence of temperature drift and external vibration on the orientation. (Received 23 Jun 86.)

9717

THRESHOLD, CHANGE CHARACTERISTICS OF PHOTOLITHOGRAPHICAL RATE IN LASER-INDUCED  
GAS-PHASE THERMOCHEMICAL PHOTOLITHOGRAPHY

40090033 Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese  
Vol 14 No 10, 20 Oct 87 pp 614-617

[English abstract of article by Li Ding [2621 0002], et al., of Shanghai  
Institute of Laser Technology; Kuang Zhong [0562 1813] of Northwest Tele-  
communications Engineering Institute, Xi'an]

[Text] Semiconductor materials, such as Ge, InP, etc., were investigated by  
laser-induced chemical photolithography with an argon ion laser. Two kinds  
of thresholds of light intensities were observed respectively for the scanning  
photolithography on the surface and the rapid penetrated etching. The former  
has a lower threshold and the latter higher, depending on the melting point.  
There exists a complicated relationship between the etching rate and the  
light intensity. The etching rate decreased with the increase in the etching  
depth. Semiconductor species with higher dopant concentrations were etched  
faster than those with lower dopant concentrations. (Received 25 Jul 86.)

9717

TREATMENT OF PCB WASTES BY COMPOSTING FERMENTATION

40081016b Beijing HUANJING KEXUE XUEBAO [ACTA SCIENTIAE CIRCUMSTANTIAE] in Chinese Vol 7, No 2, Jun 87 pp 207-211

[Article by Yue Guichun [2588 6311 2504] of the Department of Chemistry, Jilin University: "Experimental Study of Degradation of Polychlorinated Biphenyls by Composting Fermentation"]

[Text] Abstract: Composting fermentation can effectively degrade polychlorinated biphenyls (PCBs). Laboratory experiment showed that Aroclor 1016 and Aroclor 1254 degraded to some extent in a mixture of wood chips and table scraps or activated sludge. The maximum removal efficiency is 60 percent.

Keywords: composting fermentation, PCB

I. Introduction

Because of its high toxicity and difficulty to degrade, many countries stopped producing and using PCB. China has produced and used PCB for 10 years. We also have the same PCB contamination problem[1]. In recent years, many Chinese scientists initiated a number of studies related to PCB [2,3]. The work focused on analysis and quantitative determination. There has been no study on the treatment reported. A lot of work has been done in other countries on PCB treatment techniques [1,4]. One way to effectively process PCB is by using microorganisms [5]. It is very important to study the feasibility and degradation efficiency under different conditions in various systems.

This study uses the composting (mixed culture) fermentation method. In this process, PCB pollution is removed by degradation with the help of microorganisms. Composting fermentation is a widely used treatment for solid wastes. The advantage is that it is an exothermic reaction. The microorganism feeds on the organic pollutant and releases energy in the metabolic process to maintain the system at a certain temperature. No additional energy is needed. The selection of the constituents of composting system and its operating conditions is the first problem to address in PCB degradation. We tested materials such as cut up newspaper, cut up cardboard, dry leaves, wood chips, horse manure, dinner table scraps, activated sludge and corn starch. In addition to 32°C and 50°C, 20°C was used as the degradation temperature.



The corresponding habituation temperature started at 15°C and finally rose to 25°C. Our experimental result showed that a composting system containing wood chips and table scraps or activated sludge could effectively degrade PCB.

It is estimated that 70-80 percent of the PCB produced in Japan and America found its way to the environment with three fourths of it buried or left in dumps[1]. Therefore, it is significant to study treatment of PCB by composting or degradation in the rubbish pile.

Aroclor 1016 and Aroclor 1254 were used in the experiment. They are commonly used as dielectric fluids, combustion resistant additives and hydraulic fluids. Aroclor 1016 is primarily a polytrichloro-biphenyl mixture. It contains approximately 56 percent of 2,5,2' and 2,4,4' polytrichloro-biphenyl, 20 percent 2,4' polydichloro-biphenyl, and 21 percent polytetrachloro-biphenyl. Aroclor 1254 is primarily a polypentachloro-biphenyl mixture. It contains 53 percent of 2,3,6,2',4' and 2,4,5,3',4' polypentachloro-biphenyl, 22 percent 2,4,6,3',4'5' polyhexachloro-biphenyl, 19 percent 2,5,2',5' polytetrachloro-biphenyl, and the balance as polytrichloro and polyheptachloro-biphenyls. The chromatograms of Aroclor 1016 and Aroclor 1254 are shown in Figures 1 and 2, respectively.

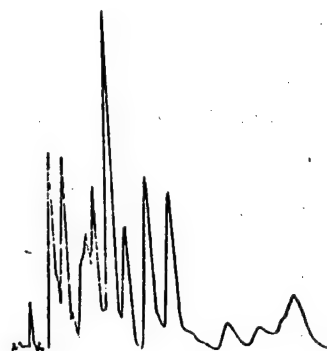
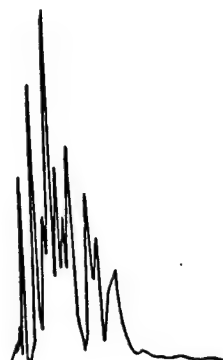


Fig. 1. Chromatogram of Aroclor 1016    Fig. 2. Chromatogram of Aroclor 1254

## II. Reagent, Instrument and Method

Aroclor 1016 (Supelco Inc.); Aroclor 1254 (Supelco Inc.); acetone (L.R.); hexane (pesticide grade); isooctane (pesticide grade); evaporation extractor (Wheaton Glass Co.); rotary evaporator (Wheaton Glass Co.); rolling mixer (New Brunswick Scientific); and Gas Chromatograph (Varian Model 3700).

### 2. Preparation of the Mixture

30 mg of Aroclor 1016, or Aroclor 1254, was dissolved in 1 liter of acetone. The solution was then mixed uniformly with 1.0 kg of dried wood chips. It was placed in a ventilation hood for 24 hours to allow the acetone to evaporate [6,7].

Table scraps from the dining room were mixed, pressed dry and kept in refrigeration.

Activated sludge from the sewage treatment plant was filtered, pressed dry and refrigerated [8].

500 g of one of the PCB containing wood chips was mixed with an equal amount of table scraps. 500 g of the PCB containing wood chips and an equal amount of activated sludge were also mixed. These four mixtures were stored individually in 19-liter narrow mouth flasks. Tap water was added to maintain its humidity at 45 percent. They were put on the Rollacell for 16 hours to be mixed thoroughly. Then, they were placed in a culture box to be habituated for a week. The temperature rose from 30°C and finally to reach 50°C.

### 3. Laboratory Fermentation Device and Experimental Conditions

Laboratory fermentation was done by putting 80 g of the habituated mixture into a 250 ml flask. The flask has a ground glass stopper top. The stopper has a gas inlet and an outlet. The inlet goes all the way down to the bottom. Air was sent in through the inlet at 30 ml/min.

Seven specimens of each of the four mixtures described above were degraded at 32°C and 50°C, respectively. One specimen was taken out every week to be stored in a refrigerator to be analyzed later.

In order to determine the effect on the PCB content on the degree of degradation, another series of experiments at different PCB levels were carried out using Aroclor 1016 and activated sludge at 32°C. In these experiments, the gas outlet was equipped with a polyurethane filter to absorb PCB and its decomposition products.

### 4. Sample Analysis

Defrosted samples were transferred from flasks to culture dishes to be baked dry at 103°C for 24 hours. Two 2-g of each of the dried samples were carefully weighed in aluminum dishes. The sample was transferred into an evaporation extractor and 50 ml of doubly distilled water was then added. Two ml of isooctane was added to the upper part of the evaporation extractor. When the water at the bottom boiled, the steam carried the PCB in the specimen up to be extracted by the isooctane. It was kept boiling for 4 hours. After it cooled down, the isooctane was removed. The vessel was rinsed with 2 ml of fresh isooctane. Both isooctane samples were collected in a 5 ml vessel and diluted to the mark ready for chromatographic analysis.

Heptane was used to rinse down the materials absorbed by the polyurethane filter into a beaker. It was placed in a rotary evaporator in partial vacuum at 60°C to reduce the volume to approximately 3 ml. It was then transferred to a 10 ml volumetric flask to be diluted to the mark waiting for chromatographic analysis [9,10].

Gas chromatography was used to quantitatively determine Aroclor 1016 and Aroclor 1254. The chromatograph is equipped with a CDS111 data processing system and a  $^{63}\text{Ni}$  electron capture detector. The area under the peaks was used to calculate the PCB concentration. The area under the PCB peaks at 0 hour degradation time is used as 100 percent to calculate the percent of PCB degraded at a given time.

The chromatograph was operated under the following conditions:

The 2m x 2mm column filled with 5 percent SP 2250 and 1.9 percent SP 2401; column temperature 200°C; detector chamber temperature 300°C; carrier gas helium at 60 ml/min.

### III. Results and Discussion

The PCB content in the mixture after one week of habituation was used as the initial concentration prior to degradation. The area under the PCB peak of each mixture is considered as 100 percent in calculating the percentage of degradation.

After seven weeks of fermentation, the percentages of PCB degradation are shown in Figures 3 through 6.

From these experimental results we can see that PCB degraded more in mixtures containing activated sludge. This is because the microorganism cultured in the mixture has a higher PCB degradation efficiency.

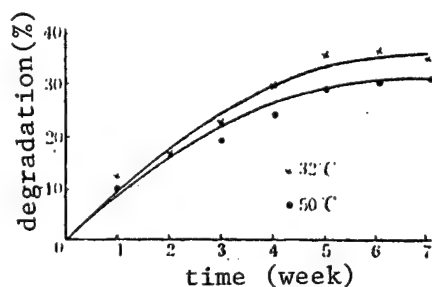


Fig. 3. Degradation of Aroclor 1016 in Composting with Table Scraps

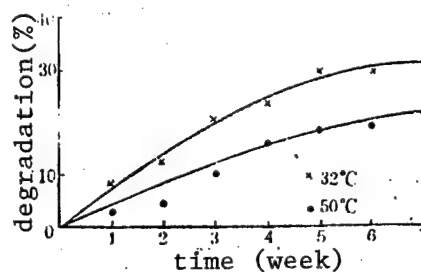


Fig. 4. Degradation of Aroclor 1254 in Composting with Table Scraps

Temperature also has a different effect on the two different mixtures. In activated sludge, 50°C is better than 32°C for PCB degradation. In table scraps, it is the opposite. It is thought that different microorganisms might be responsible for PCB degradation in these two types of mixtures. In the latter case, the growth of the PCB degrading microorganism might be suppressed by high temperature.

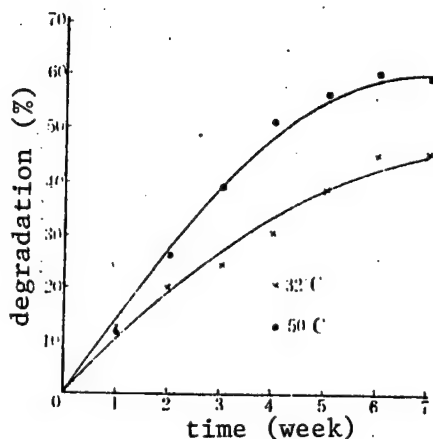


Fig. 5. Degradation of Aroclor 1016 in Composting with Activated Sludge

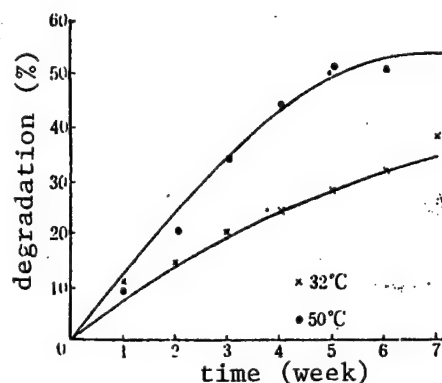


Fig. 6. Degradation of Aroclor 1254 in Composting with Activated Sludge

The effect of PCB content on its degradation was studied with Aroclor 1016 in activated sludge after three weeks of degradation at 32°C. The result is listed in Table 1. It shows that the PCB content had no significant influence on its degradation within the range tested.

Table 1. Influence of PCB Content on the Degradation

Aroclor 1016( $\mu\text{g/g}$ )	degradation (%)
6.1	26.1
12.5	28.3
21.3	29.2
27.7	24.5
32.3	25.8
39.0	26.7

Analyses of the polyurethane showed no PCB absorption. The decrease in PCB level in the mixture was due to degradation by the microorganism. It was not carried out by the gas flow. In addition, a yellow substance was found on the polyurethane filter which could be dissolved in hexane. It might be a PCB decomposition product.

#### IV. Conclusions

Based on the laboratory experiment described above, we know that:

1. PCB wastes can be effectively treated by composting fermentation. After screening a variety of constituents, activated sludge and table scraps were found to be most effective. Based on laboratory tests with Aroclor 1016 and

Aroclor 1254, when PCB content was of the order of  $\mu\text{g/g}$  in the mixture, 60 percent of the PCB was degraded after seven weeks of fermentation.

2. Temperature definitely has an effect on PCB degradation.
3. With Aroclor 1016, when the PCB content is below 39.0  $\mu\text{g/g}$ , its level has no effect on its degradation.
4. In the two systems studied, Aroclor 1016 is more readily degradable than Aroclor 1254.

This experiment was completed at the Rutgers University in the United States. The author wishes to acknowledge the support and assistance from Professor Hunter during the course of this work.

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12553/7358

STUDY ON PREVENTION, CONTROL OF URBAN AIR POLLUTION

40081016a Beijing HUANJING KEXUE XUEBAO [ACTA SCIENTIAE CIRCUMSTANTIAE] in Chinese Vol 7, No 2, Jun 87 pp 123-129

[Article by Li Yimin [2621 0001 3046] of Tianjin Institute of Environmental Protection, and Zhang Shiyong [1728 0013 5391] and Tao Jin [7118 3160] of the Institute of Systems Engineering, Tianjin University; manuscript received 3 Sep 86: "A Study on Protection and Control of Urban Air Pollution"]

[Text] Abstract: This paper describes a model for atmospheric environment, energy and economic planning based on an atmosphere diffusion model and a mathematical planning model to reflect the urban layout, energy consumption structure and environmental quality. The city of Tianjin is used as an example to discuss the comprehensive pollution prevention scheme.

Keywords: air pollution control, multi-objective programming, air quality

I. Introduction

Some countries and areas use the total quantity of emission to control urban pollution. For instance, Japan adopted total quantity control in its "Air Pollution Control Act of 1975." In 1979 Shenyang established a total quantity control computer model for sulfur dioxide with good prevention results. However, in an old industrial city like Tianjin with many outdated, low efficiency, low discharge capacity energy conversion devices scattered around and where the efficiency of dust removal equipment is generally poor, it is difficult to implement total quantity control. Therefore, the use of a comprehensive control method is an important and feasible way to manage air pollution.

First, we must study the current situation and identify the sources of pollution in order to build a comprehensive prevention system. Furthermore, a model correlating economic development, energy demand and air quality will be established based on the air quality goal, planned economic growth, urban layout and projected energy consumption as a tool in planning and evaluating air pollution control. In this paper, a comprehensive plan to prevent air pollution and control sulfur dioxide and suspended particulates in Tianjin is presented.

The study of urban air pollution prevention and control is a multi-objective, multi-layer, multi-factor system including situation assessment, environmental improvement study and energy demand projection. It also includes the environmental, economic and energy planning model as shown in Figure 1.

At present, air pollution in most cities in China is from burning coal. The major pollutants are sulfur dioxide and particulates. Sulfur dioxide primarily comes from coal. Its distribution is identical to the distribution of coal burning sources. Based on the statistical data of Tianjin in 1983, the amounts of sulfur dioxide discharged from various sources are listed in Table 1. (The particle diameter distribution ranges from 0.38 to 5.78  $\mu\text{m}$ .)

Fly ash is another air pollutant. Its concentration and particle size distribution belongs to an urban dual model and has normal distribution. The mean diameter is  $2.35 \pm 0.40 \mu\text{m}$ . 41.3 percent of the total ash is fine particles under 1.5  $\mu\text{m}$  in diameter. Using chemical mass balance and factor analysis, it was determined that the fly ash in Tianjin primarily comes from coal burning and wind blown dust. The different sources are listed in Table 2.

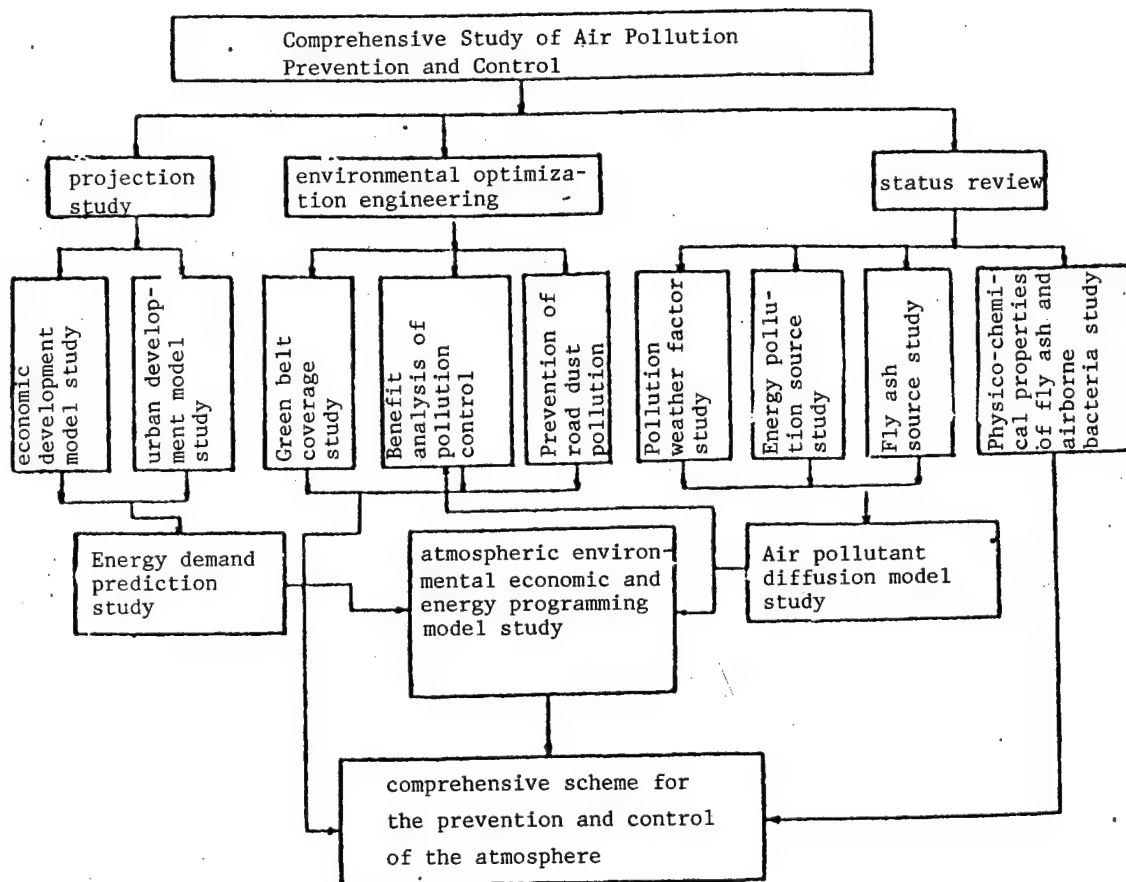


Figure 1. The Scheme of the Study

Table 1. Sulfur Dioxide Emission in Tianjin by Category (t)

period \ type	key point source	general point source	general plane source	inhabitant plane source	total
heating season	5523	1182	4407	1273.9	12385.9
non-heating season	3544	525	1612.7	463.8	6145.5
year round	50444	8928	30530	8806	98708
percent (%)	51.1	9.05	30.93	8.92	100

Table 2. Fly Ash Source Distribution

source \ percent	percent (%)		
	heating season	non-heating season	mean value
dust	29.20	40.68	34.94
coal burning	49.00	38.24	43.62
automobile	10.40	10.20	10.30
fuel oil	4.00	4.30	4.15
secondary pollution	5.60	0.90	2.25
other	5.30	4.90	5.10

## II. Urban Energy Resource and Energy Consumption Prediction

Coal is the primary urban energy resource in China. The supply and distribution of energy resources determines the basic air pollution characteristics. Therefore, it is necessary to study the industrial, economic and urban planning of the city to ascertain the energy demand and supply of various functional areas and organizations to predict the air quality. Figure 2 shows the scheme adopted to predict urban energy demand.



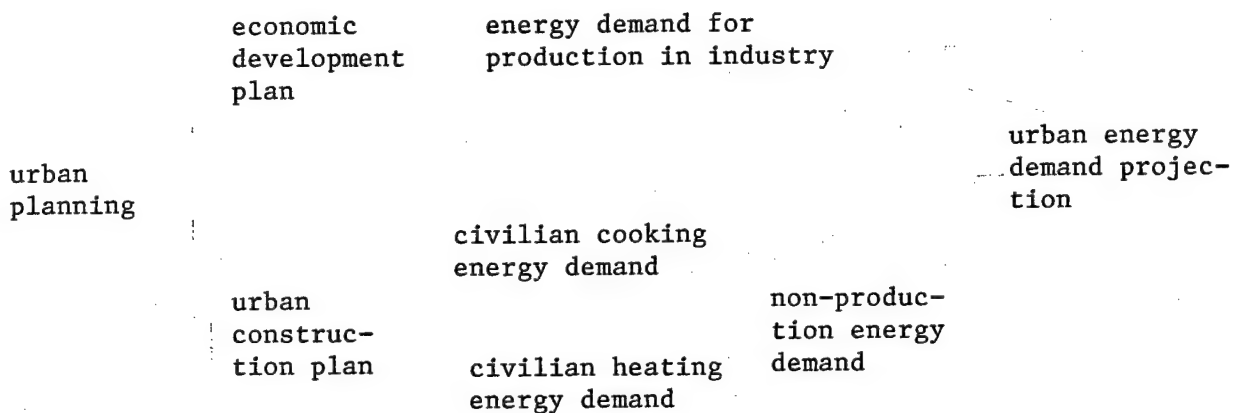


Figure 2. Program Scheme for Urban Energy Demand Projection

### III. Environmental, Economic and Energy Planning Model

This model reflects the mutual relation of urban economic development, industrial layout and environmental quality in order to coordinate and analyze the situation by means of optimization. This model provides a basis for drafting urban pollution prevention and control plans.

#### 1. Characteristics of Programming Model

The model is a multi-objective linear model. The objectives are to meet air quality standards, to make rational investments and to conserve energy. It is a multi-policy making problem. The special feature is that the entire city is divided into small functional zones based on the future plan, present status and characteristics of the functional area. In the model, each small zone has its own variables, instead of setting variables for the whole city. Thus, the effect of the layout of the city on its air quality can be studied.

The concentration of the pollutant in the air, instead of the total emission, is used to describe air quality. It better reflects the effect of environmental quality to the ecology.

An environmental target function is set up for each zone. The variables are the fuels consumed in a unit of time by various devices. The energy flux is converted into concentrations of various air pollutants through a conversion factor - pollution contribution factor. This factor represents the contribution of pollutant concentration in the area from various emission sources in a certain zone. It is determined from a mathematical atmosphere-diffusion model--a combination of modified Gauss diffusion model from a point source and elevated plane source diffusion model. By introducing the pollutant concentration contribution factor into the programming model, and by combining the atmosphere-diffusion model with the multi-objective programming model, the model has the capability to assess the impact of urban layout on air quality. It can also directly point out the investment required to manage major pollution sources from any functional zone.

## 2. Multi-Objective Programming Model and Its Solution

### (1) Target Function

The environment target includes functions for sulfur dioxide and fly ash, i.e.

$$SO_2(k) = \sum_j \sum_{i \in I_j} S_{ji}^k x_i, \quad k=1, 2, 3, \dots, l; \quad (1)$$

and

$$P(k) = \sum_j \sum_{i \in I_j} P_{ji}^k x_i, \quad k=1, 2, 3, \dots, l. \quad (2)$$

In equations (1) and (2),  $S_{ji}^k$  represents the contribution factor from a unit of energy consumed by the  $i$ th energy supply mode in zone  $j$  to the sulfur dioxide concentration in zone  $k$ .  $P_{ji}^k$  represents the contribution factor from emission source  $i$  in zone  $j$  to the fly ash concentration in zone  $k$ .  $I_j$  is the corresponding target set  $x_i$  for zone  $j$ .  $x_i$  is the energy flux and  $l$  is the number of zones.

### Investment Objective

$$INV = \sum_{i \in I} C_i \left( \sum_{j \in J_i} x_j \right). \quad (3)$$

In equation (3),  $C_i$  is the investment coefficient to control a type of source.  $I$  and  $J_i$  ( $i \in I$ ) are the corresponding target sets.

### Energy Consumption Goal

$$E = \sum_{i \in I} k_i \left( \sum_{j \in J_i} x_j \right). \quad (4)$$

In equation (4),  $k_i$  is the conversion factor to convert an energy resource to standard coal.

### (2) Constraints

Constraints reflect the inter-dependency among factors to be programmed. They include:

- a. demand constraint such as ultimate industrial demands (boilers, furnaces and electricity), cooking, heating and electricity demands;
- b. industrial boiler and furnace power demand, cooking and heating loads in each small functional zone;

c. constraints imposed by the government on certain fuels such as oil and natural gas;

d. constraints reflecting certain equilibrium relations in energy distribution.

The model described above is summarized into a multi-objective linear programming model:

$$\begin{aligned} & \text{Min}(\text{SO}_2(k), P(k), \text{INV}, E) \\ & \text{s.t} \quad AX \leq b \\ & \quad \quad X \geq 0 \end{aligned} \quad (5)$$

A is the coefficient matrix (mxn) corresponding to the constraints and b is the constraint vector. The above equation can be re-written into a vector form.

$$\begin{aligned} & \text{Min} \quad Z = CX \\ & \text{s.t} \quad AX \leq b \\ & \quad \quad X \geq 0 \end{aligned} \quad (6)$$

C is a (kxn) matrix where k is the target function number and n is the number of variables.

The optimization of a multi-objective programming model should reflect added message of the decision maker. In general, the decision maker has certain requirements on the range of value of each target function. For instance, the air quality requirement in an industrial zone is lower than that in a residential zone. Under the premise of economic feasibility, priority is given to investments which treat pollution sources sensitive to the public. In order to utilize these requirements as the decision maker is expecting, a fuzzy scheme was used to solve the multi-objective model to allow the decision maker to choose from several policies developed by the model.

To this end, equation (6) can be expressed in the fuzzy problem format:

$$\begin{aligned} & CX \lesssim Z_0 \\ & AX \lesssim b \\ & X \geq 0 \end{aligned} \quad (7)$$

where  $Z_0$  is the level of the target value expected by the decision maker.

#### IV. Real Example Analysis

Based on a rigorous analysis of the environmental targets, economic growth indicators and pollution control resources determined by the policymaker, from the environmental benefit analysis on natural gas, thermal grid and centralized heating plan for Tianjin and the results of a computation based

on the planning model and atmosphere diffusion model, the amounts of sulfur dioxide, fly ash and other coal burning pollutants from 1980 - 2000 in Tianjin are shown in Figures 3 - 5.

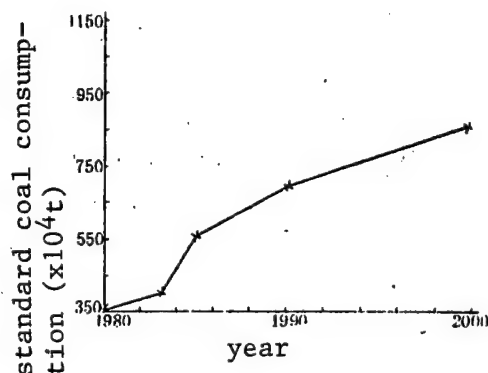


Figure 3. Changes in Coal Consumption in Urban Tianjin

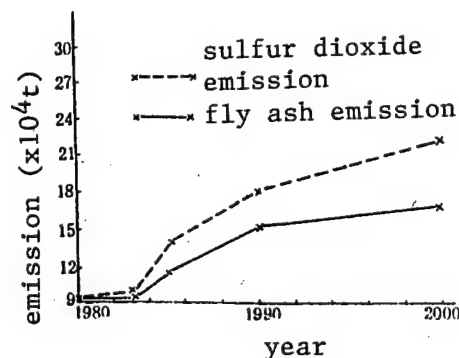


Figure 4. Changes in Emission from Coal Burning

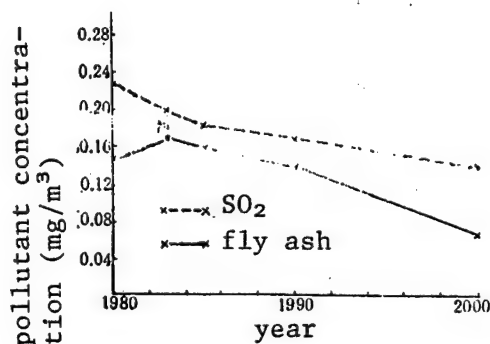


Figure 5. Change in Air Pollutant Concentration from Coal Burning

From 1980 to 1985, although the coal consumption and emission of pollutants were raised by a factor of 0.5, due to the re-arrangement of the industrial layout, emission site height increase and decrease in the number of single story houses, the concentration of SO<sub>2</sub> and fly ash began to drop since 1983. Based on the thermal grid program planned for Tianjin, since the First Power Plant was converted to a thermal power plant in 1984, several thermal power plants will be built in industrial areas before the year 2000 to take care of the heating needs of the residents. Centralized boilers will be constructed in residential areas to gradually replace the present outdated, inefficient, low altitude emission, heating equipment. It is expected to take care of 29 percent of the industrial heat demand by 1990. By 2000, civilian and industrial thermal rates will be raised to 90 and 56 percent, respectively. The SO<sub>2</sub> level in urban Tianjin will reach 0.14 mg/m<sup>3</sup> and fly ash level will be 0.06 mg/m<sup>3</sup> (see Figure 5).

Let us use the industrial zone in southeast Tianjin as an example to discuss the special feature of studying environmental analysis by zone. By 1990, the heat load for the 313 factories with 381 boilers above 4 tons and 412 water heaters and the hot water and heating for the  $346 \times 10^4$  m<sup>2</sup> of residential space will be supplied by two thermal power plants to replace  $86 \times 10^4$  t/a of coal consumption. This reduces SO<sub>2</sub> and fly ash emission by  $2.1 \times 10^4$  t/a and  $0.95 \times 10^4$  t/a, respectively. The improvement in air quality in that region is shown in Table 3.

Table 3. Change in Air Quality of Industrial Area in Southeast Tianjin

pollutant	stability	pollutant concentration (mg/m <sup>3</sup> )		decrease (%)
		before	after	
coal	A-B	0.085	0.0198	77
	C	0.110	0.0205	81
ash	D	0.135	0.0175	87
	E-F	0.285	0.0507	86
SO <sub>2</sub>	C	0.37	0.0592	84

From the angle of improving air quality, in addition to following urban planning to build a 500 m wide green belt of fruit trees around Tianjin as a protective forest, other forest belts and green belts are also being built. A wide isolation belt will be built on both east and west side of the Haihe industrial zone to form a green belt system. In the near future, bare ground will be eliminated inside the middle loop. By 2000, all exposed land will be planted.

Based principally on changing the fuel structure, and assisted by measures such as green belts, ground covering and automobile pollution control, the air quality in Tianjin can meet the target by 2000. Sulfur dioxide and particulates will meet the second level of standards. The total investment is approximately 1.5 billion yuan.

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12553/7358

NEW AIR POLLUTION PREVENTION, CONTROL LAW IN EFFECT

Beijing RENMIN RIBAO in Chinese 10 Sep 87 p 5

[Article: "Air Pollution Prevention and Control Law of the People's Republic of China; Passed on 5 Sep 1987 at the 22nd Session of the Standing Committee of the Sixth National People's Congress"]

[Text] Chapter One: General Principles

Article One: This law is formulated to prevent air pollution, safeguard and improve the living environment and the ecological environment, guarantee physical health and promote the development of socialist modernization.

Article Two: The State Council and local people's governments at all levels must make atmospheric environmental protection a part of national economic and social development plans and plan sensibly the distribution of industries, intensify scientific research to prevent air pollution, adopt measures to prevent air pollution and safeguard and improve the atmospheric environment.

Article Three: The environmental protection departments of people's governments at various levels are the agencies which carry out unified supervision and management of air pollution prevention and control.

It is the responsibility of public safety, transportation, railway and fisheries management departments at all levels to carry out supervision and management of motorized vehicle and boat pollution of the atmosphere.

Article Four: Units which discharge pollutants into the atmosphere must obey relevant national stipulations and adopt pollution prevention and control measures.

Article Five: Each unit and individual has the duty to safeguard the atmospheric environment and has the right to report and accuse a unit or individual which is polluting the atmospheric environment.

Article Six: The Environmental Protection Department of the State Council formulates national atmospheric environmental quality standards.

The people's governments of provinces, autonomous regions and municipalities directly subordinate to the central government may formulate local standards

in any area where there are none in the national atmospheric environmental quality standards and report them to the State Council's Environmental Protection Department for the record.

Article Seven: The Environmental Protection Department of the State Council formulates national air pollutant discharge standards on the basis of the national atmospheric environmental quality standards and national economic and technological conditions.

The people's governments of provinces, autonomous regions and municipalities directly subordinate to the central government may formulate local discharge standards in any area where there are none in the national air pollutant discharge standards; for areas for which standards have been formulated in the national air pollutant discharge standards, local discharge standards more strict than the national discharge standards may be formulated. Local discharge standards must be reported to the The Environmental Protection Department of the State Council for the record.

All those who discharge air pollutants in areas which have local discharge standards should observe local discharge standards.

Article Eight: Units and individuals who have made obvious achievements in preventing air pollution, safeguarding and improving the atmospheric environment will be rewarded by people's governments at the various levels.

## Chapter Two: Supervision and Management of Air Pollution Prevention

Article Nine: New construction, expanded construction and transformed construction projects which discharge pollutants into the atmosphere must obey relevant state construction project environmental protection and management stipulations.

Environmental impact reports for construction projects must evaluate the air pollution which the construction project might produce and the impact on the ecological environment, stipulate prevention and control measures and receive the approval of the environmental protection department in line with the stipulated procedures.

Before a construction project goes into production or is used, its air pollution prevention and control measures must be reviewed by the environmental protection departments. Construction projects which do not meet the demands of relevant state construction project environmental protection and management stipulations may not go into production or be used.

Article Ten: Units which discharge pollutants into the atmosphere must report to the local area's environmental protection department, in accord with the stipulations of the State Council's Environmental Protection Department, the pollutant discharge facilities and processing facilities they possess and the classes, quantity and concentrations of pollutants discharged under normal operating conditions, and provide relevant technical materials on preventions of air pollution.

Those which have great variation in the classes, quantities and concentrations of pollutant discharge must report promptly. Those which have removed or left idle pollution control facilities should request the agreement of the local environmental protection department.

Article Eleven: Those units which discharge pollutants into the atmosphere in excess of the stipulated discharge standards should adopt effective control measures and pay expenses for the pollution discharged above the standards in accordance with state stipulations. Expenses for excess pollution received must be used for pollution prevention and control.

Institutions which cause severe air pollution must control it within a limited time.

Article Twelve: No industrial production facilities which pollute the environment may be constructed within areas designated by the State Council and people's governments of provinces, autonomous regions or municipalities directly subordinate to the central government as famous scenic areas, nature protection areas and other areas requiring special protection; in constructing other facilities, the pollutants discharged may not exceed the stipulated discharge standards. Institutions whose facilities were constructed before this law goes into effect and whose discharge of pollutants exceeds the stipulated discharge standards must control it within a limited time.

Article Thirteen: Control deadlines for institutions under the jurisdiction of people's governments of municipalities and counties or below municipalities and counties will be proposed by the environmental protection departments of the municipal and county people's governments and reported to the people's governments at the same level for decision. Control deadlines for institutions under the direct jurisdiction of the central government or the people's governments of provinces, autonomous regions and independent municipalities will be proposed by the environmental protection departments of peoples governments of provinces, autonomous regions and municipalities directly subordinate to the central government and reported to the people's governments at the same level for decision.

Article Fourteen: Units which, due to accident or other sudden incident, discharge and release toxic and harmful gasses and radioactive material which creates or can create air pollution accident or endangers peoples' health must immediately adopt emergency measures to prevent air pollution danger, inform the units and citizens who may be endangered by air pollution and report to the local environmental protection department and be investigated and dealt with.

Under emergency situations in which the atmosphere is seriously polluted endangering people's health and safety, the local people's government must adopt strong emergency measures, including instructing the polluting unit concerned to halt discharge of pollutants.

Article Fifteen: Environmental protection departments and other monitoring and control departments have the right to carry out on-site inspections of polluting units within their jurisdiction, and the unit being inspected will



provide the necessary materials to accurately reflect the situation. The inspecting departments have the duty to maintain the technological security and professional security of the unit being inspected.

Article Sixteen: The State Council's Environmental Protection Department should establish an air pollution monitoring system, set up a monitoring network and draw up unified monitoring methods.

### Chapter Three: Prevention and Control of Smoke Pollution

Article Seventeen: Relevant State Council departments in charge should, on the basis of the boiler smoke discharge standards stipulated by the state, stipulate corresponding demands in boiler product quality standards; boilers which do not meet the stipulated demands may not be manufactured, sold or imported.

Article Eighteen: Smoke discharge of newly constructed industrial kilns and newly installed boilers may not exceed stipulated discharge standards.

Article Nineteen: Urban construction should implement unified planning to unify resolution of heat sources and develop centralized heat supply.

Article Twenty: Relevant departments of the State Council and local people's governments at all levels should adopt measures to improve urban fuel structure, develop urban coal gas, and promote the production and use of formed coal.

Article Twenty-one: In areas of dense population where coal, coal gangue, coal cinders, coal ash, and bone coal are deposited, measures to prevent fire and dust must be adopted to prevent polluting the atmosphere.

### Chapter Four: Prevention and Control of Pollution by Waste Gas, Dust and Offensive Odors

Article Twenty-two: Discharge into the atmosphere of dust and waste gasses containing toxins is to be strictly controlled; if they must be discharged, they should be purified so as not to exceed the stipulated discharge standards.

Article Twenty-three: Combustible gasses produced in industrial production should be recovered and used and those which do not have recovery and utilization conditions and discharge them into the atmosphere should carry out prevention and control of pollution.

Those which discharge into the atmosphere converter gas, acetylene, electric furnace yellow phosphorous tail gas, and organic hydrocarbon tail gas must report to the local environmental protection department for approval.

Those which must discharge combustible gases because they cannot operate normally if recovery equipment is used should fully burn the combustible gases discharged or adopt other measures to reduce hydrocarbon air pollution.

Article Twenty-four: Those which, in the process of refining petroleum, producing synthetic ammonia, coal gas and coking, and ferrous metals refining, discharge gas containing sulfides should be equipped with desulfurizing equipment or adopt other desulfurizing measures.

Article Twenty-five: Discharge into the atmosphere of gases and aerosols which contain radioactive materials must comply with relevant state stipulations on radioactive prevention and not exceed the stipulated discharge standards.

Article Twenty-six: Units which pollute the air by discharging gases with offensive odors must adopt measures to prevent pollution of the surrounding residential neighborhood.

Article Twenty-seven: Units which pollute the air by discharging dust must adopt dust prevention measures.

Article Twenty-eight: Burning asphalt, asphalt felt, rubber, plastic, leather and other substances which produce noxious and harmful smoke and offensive odors is prohibited in areas of dense population; under special conditions when they must be burned it must be reported to the local environmental protection department for approval.

Article Twenty-nine: For transporting, loading and unloading and storage of substances which can give off noxious and harmful gases or dust, sealing measures or other protection measures must be adopted.

Article Thirty: Control measures should be adopted for discharge of pollutants into the air by motorized vehicles and boats may not exceed the stipulated discharge standards and for motorized vehicles and boats which exceed the stipulated discharge standards. Automobiles whose discharge of pollutants exceeds the discharge standards stipulated by the state may not be manufactured, sold or imported. Specific supervision and management methods will be stipulated by the State Council.

#### Chapter Five: Legal Responsibility

Article Thirty-one: Those who violate the stipulations of this law by one of the following behaviors, the environmental protection department or other supervisory and control departments may, depending on the situation, be warned or punished:

(1) Those who refuse to report or give false information concerning a relevant pollution discharge incident stipulated by the State Council's Environmental Protection Department;

(2) Those who, without the agreement of the environmental protection department, remove or idle on their own pollution prevention and control facilities so that the pollution discharge exceeds the stipulated discharge standard;

- (3) Those who resist an on-site inspection by the environmental protection department or other supervisory and management department or who resort to deception at the time of an inspection;
- (4) Those who violate Article Twenty-eight of this law by burning asphalt, asphalt felt and other substances which produce noxious and harmful smoke and offensive gases;
- (5) Those who do not pay expenses for exceeding pollutant discharge standards according to state stipulations.

Article Thirty-two: For those who have not constructed air pollution prevention facilities at a construction project or those which do not meet the relevant state construction project environmental protection and management stipulation demands and put them into production or use, the environmental protection department which approved the construction project's report will order that production be stopped or used and can issue a fine.

Article Thirty-three: Institutions which go beyond the control deadline and have not yet completed their control mission, in addition to the addition of excess pollutant discharge expenses according to state stipulations, may also be fined depending on the harmful consequences they caused or be ordered to stop and shut down.

Fines are determined by the environmental protection department. Stop and shut down orders are decided by the people's government which set the control deadline; ordering the stop and shut down of institutions directly under the jurisdiction of the central government must be approved by the State Council.

Article Thirty-four: Institutions which violate the stipulations of this law and cause air pollution accidents will be fined by the environmental protection department on the basis of the harmful consequences they caused; in serious cases the personnel responsible will be administratively punished by their unit or the upper level agencies in charge.

Article Thirty-five: In cases in which the parties do not obey the administrative punishment decisions, within fifteen days of receiving the notification of the punishment decision, suit may be brought in people's courts; for those who do not fulfill it within the specified time, the agency which issued the punishment decision is to petition the people's court to coerce compliance.

Article Thirty-six: Units which create air pollution danger have the responsibility to eliminate the danger and compensate units or individuals for losses directly suffered.

Disputes of compensation responsibility or compensation funds may be handled by the environmental protection departments on the basis of the request of the parties; for those parties which do not obey the disposition decision, suit may be brought in people's court. The parties can also directly bring suit in people's courts.

Article Thirty-seven: Instances in which losses were suffered entirely due to irresistible natural disasters and for which measures were adopted promptly but air pollution was still unavoidable, are blameless.

Article Thirty-eight: For all those who create serious air pollution accidents the serious consequences of which lead to severe loss to public and private property or injury and loss of life, the relevant personnel responsible can be investigated for criminal responsibility according to the stipulations of Article 115 or Article 187 of the "Criminal Code of the People's Republic of China."

Article Thirty-nine: Those environmental protection supervision and management personnel who abuse their authority or neglect their duty will be administratively punished; those which constitute crimes shall be investigated for criminal responsibility according to the law.

#### Chapter Six: Supplementary Articles

Article Forty: The State Council's Environmental Protection Department will formulate and implement detailed rules and regulations of this law and report to the State Council for approval and enabling.

Article Forty-one: This law is in force effective 1 June 1988.

#### Appendix:

##### Relevant articles of the criminal law

Article One-hundred-fifteen: Those who cause severe consequences due to violating the stipulations for management of explosive, combustible, toxic, and corrosive products and bringing about major accidents in production, storage, shipping or use are sentenced to up to three years of imprisonment or detention; for those consequences which are especially severe, are sentenced to up to seven years imprisonment.

Article One-hundred-eighty-seven: Those state workers who, due to dereliction of duty, cause severe loss to public property and the interests of the state and people are sentenced to up to five years imprisonment or detention.

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CSO: 4008/1014

CRYSTALLOGRAPHY IN DESIGN OF PROTEIN ENGINEERING REPORTED

40091007 Beijing SHENGWUHUAXUE YU SHENGWUWULI JINGZHAN [PROGRESS IN BIOCHEMISTRY AND BIOPHYSICS] in Chinese No 2, Apr 87 pp 2-10

[Article by Lu Guangying [4151 0342 3853] of the Department of Biology, Beijing University]

[Abstract] The paper presents the recent achievements and progress of protein engineering, as well as the major role played by the protein X-ray crystallography technique in the design of protein engineering. Several actual cases are cited to explain how to use protein crystal structure data in design work in protein engineering: tyrosyl-tRNA synthetase, dihydrofolate reductase, T<sub>4</sub> lysozyme, c (Cytochrome c), trypsin and proinsulin. Up to the present time, detailed crystal structures of more than 150 proteins have been determined, many of which can be used as objects of protein engineering. Currently, China has the requisite conditions and is about to begin research of site-directed mutagenesis in protein engineering, with such projects as insulin, trypsin, trypsin inhibitor and alpha-high-temperature starch enzyme about to commence. Eight figures show molecular structures and hydrogen bonds in the cases cited. The paper was received for publication on 26 Sep 1986.

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## SIMPLE, EFFICIENT METHOD FOR cDNA SYNTHESIS

40081050b Beijing SHENGWUHUAXUE YU SHENGWUWULI JINZHAN [BIOCHEMISTRY AND BIOPHYSICS] in Chinese No 6, Dec 86 pp 62-65

[Article by Shen Yufei [3088 5038/33769 7236/33769], Wu Ninghua [0702 1337 5478], and Cheng Xiaokuan [4453 1420 2949] of the Basic Medicine Institute of the Chinese Academy of Medical Sciences, Beijing]

[Text] As DNA recombination techniques are ever more widely used in medical and biological realms, the separation of certain standard proteineous catalogued genes and monoclonal cells that are related to the growth, propagation and division of cells have received more emphasis. Because of the duplicating characteristics of eucaryotic gene groups and the existence of endomeres, researchers find it preferable to complementary DNA (cDNA) as the starting point of molecular cloning so that in vitro gene expression or structural analysis can be conveniently performed. Because of this, it is necessary to first obtain high quality and stable messenger RNA (mRNA) as molds for the combination of cDNA. Then cDNA can be effectively produced. We have explored different reaction systems, and this article summarizes the more satisfactory results of our experiments.

## Materials and Method

1. mRNA separation and purification: It basically followed Chirgwin's Guanidinium thiocyanate - Cesium Chloride extraction method [1] with some enhancements (hereafter GuTC/CsCl method). Five times the volume of the compressed cells guanidinium thiocyanate dialysing fluid (4M guanidinium thiocyanate, 25mM sodium citrate pH 7.0, 0.1M  $\beta$ -sulphoethanol, 0.5 percent sodium dodecyl sulfate) was added and vibrated vigorously. Then 0.4g Cesium chloride (BRL super-pure reagent) was added per ml of dialysed cell suspension. After the solution was obtained it was added to a 5.7M Cesium chloride solution containing 0.1M EDTA. The solution was centrifuged at 20°C at 150,000 x g for 12 hours. The RNA precipitate dissolved in the abovementioned guanidinium thiocyanate solution which did not contain N-sodium dodecyl sulfate. It was then extracted in equal proportions of phenol and chloroform, and precipitated by ethanol.

mRNA separation was according to that reported in the literature [2]. Oligo-dT cellulose (P-L Biochemicals, Type 7) was used in adsorption to collect

10mM Tris-Cl, pH7.5. Portions were eluted with 0.05 percent SDS. After precipitation by ethanol it was kept at -70°C.

2. cDNA combination: The combination of the first and second strands were both processed in an acetate system that did not contain chloride ions.

I. First-strand combination (pH8.3): in 50µl of pH8.3 acetate buffer system (50mM Tris-OAc, pH8.3; 138 ml KOAc, 6mM MgOZc, 10mM NaOAc, 20 mM DTT), 100 µg/ml of Oligo (dt) 12-18 (P-L Biochemicals) was used as substrate, four kinds of deoxygenated nucleotide tri-phosphate (dNTP) (P-L Biochemicals) 20 µM each, AMV reverse transcriptase (Life Science) 44u. After incubation at 37°C for 90 minutes, the solution was extracted once directly with phenol/-chloroform. It was then precipitated with NaOAc-ethanol.

II. Second strand combination (pH7.5): mRNA-cDNA hybridized double helixes were centrifuged and collected and added to 100µl of pH7.5 second-strand cDNA combination buffer (20mM Tris-OAc, pH7.5; 5 mM MgOAc, 10 mM (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>, 100 mM KOAc), then 125 µM each of 0.15mM β-NAD and four kinds of dNTP were added. After mixing, different volumes of nuclease H (RNaseH 1u/µl; P.L. Biochemicals) and colibacillus DNA polymerase 3u (5u/µl; New England Biolabs) were added. After incubation respectively in 14°C and 22°C for 1 hour each, the amount produced was calculated or analysed by electrophoresis.

III. Isotope <sup>32</sup>P- or <sup>3</sup>H- marked dNTP (Amersham): Both agarose electrophoresis and autoradiography were standard procedures in our laboratory to calculate the amount of added DNA.

Table 1. Comparison of cDNA first strand combination systems

reaction system	buffer system	anions		cations (mM)			thio-reagents	reaction temp. (°C)	relative productivity
		Cl <sup>-</sup>	OAc <sup>-</sup>	K <sup>+</sup>	Na <sup>+</sup>	Mg <sup>++</sup>			
I	Tris-OAc <sup>(33)</sup>		+	138	10	6	DTT	37	1.00
II	Tris-Cl <sup>(33)</sup>	+		140	-	10	EtSH	42	0.63
III	Tris-Cl <sup>(34)</sup>	+		50	-	10	EtSH	37	0.81

Table 2. Comparison of cDNA second strand combination systems

reaction system	buffer system(pH)	anions			cations			thio-reagents	reaction temp. °C	relative productivity
		Ac <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>+</sup>	K <sup>+</sup>	NH <sub>4</sub> <sup>+</sup>	Mg <sup>++</sup>			
I	Tris-OAc (7.5)	+		+	100	10	5	β-NAD	14/22	1.00
II	Tris-Cl (7.6)	+	+		100		10	DTT	14/22	0.51
III	HEPES (7.6) <sup>(a)</sup>		+		67.5		4	EtSH	14/22	0.25
IV	HEPES (7.6)		+		200		4	EtSH	14/22	0.26

## Results and Discussion

1. The preparation of substrate materials. In order to explore ways to produce high quality cDNA, we need to first separate intact or large fragments of mRNA as substrate. Because of this, it is necessary to prevent exogenic or endogenic RNAase activity. Currently, the recognized reagent to effectively control RNAase is RNasin. It comes from rat liver or fetal proteins; its molecular weight is approximately 40,000d. In addition, vanadyl ribonucleotide complex is also a fairly strong inhibitor. In the last few years, researchers overseas have widely used a strong denaturing agent--guanidinium thiocyanate. The strength lies in its ability to enhance nucleic acids to separate from nucleoproteins in the cell fractionation process. Also, it has a strong denaturing effect on RNAase.

Because the amount of endogenic RNAase in lymphocytes is relatively high, we used different reaction conditions and three different kinds of RNAase inhibitors. The results showed that when the reaction systems contained 1,000 u/ml of RNasin, the combined plasmic RNA and mRNA units was the highest (Figure 1), and the lowest with guanidinium thiocyanate systems. The former was triple that of the latter.

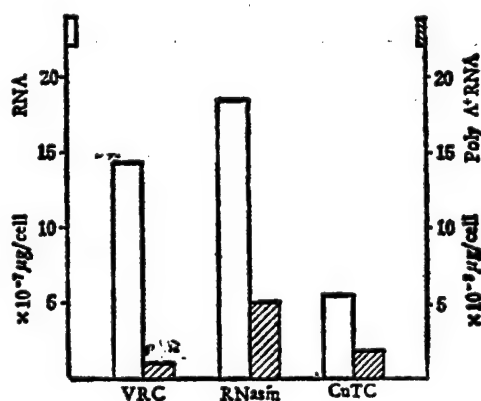


Figure 1. The effect of different RNAase inhibitors on human lymphocytes' total RNA and on RNA production rate.



When purifying mRNA, we substituted the NaCl used in Oligo (dt) 12-18 cellulose column separation system with LiCl in order to increase the flow rate. We were able to obtain better results. mRNA productivity is 1-5% of the total RNA, 1/3 of which was eluted by solutions containing 0.1M LiCl, 2/3 was eluted by solutions not containing LiCl. In using rabbit endoplasmic reticular cell fractionation systems in in vitro transcription, both portions of the elution solution showed transcription activity. Because the position of the electrophoretic regions of transcribed material were the same, we think that the portion eluted in the 0.1M LiCl solution probably included shorter polyA<sup>+</sup> mRNA. In order to avoid the problem of 12-18 Oligo-polythymidine not effectively combining with the eluted mRNA, we generally use eluted portions as the mold for reverse transcription.

Even though the GuTC/CsCl produced the least total amount of RNA and mRNA, the mRNA obtained has a higher in vitro transcription activity. Therefore, that method has become our main procedure for separating lymphocyte mRNA. When RNasin was used as the inhibitor in the extraction of mRNA, the intersample difference in transcription activity levels was fairly large. Also, there were more steps involved, larger amounts of reagents such as RNasin and proteinase K were required, and it is therefore more expensive. Therefore, this method is used only when mRNA extraction is done on plasma.

## II. mRNA reverse transcription (cDNA first strand combination).

In order to effectively reverse transcribe mRNA into cDNA, we compared three different sets of conditions at pH8.3. The results are shown in Table 1. Also, I was selected as the standard laboratory procedure.

It is apparent from Table 1 that OAc<sup>-</sup>, Na<sup>+</sup> and thio-reagents were probably the main reasons for the better reaction results. Their reaction mechanisms need further research.

In using the GuTC/CsCl method to extract mRNA as molds, the cDNA obtained has a first strand combination rate of 50-70 percent in general. At the same time, purified mRNA in ethanol kept in ethanol at -60°C for 2-3 years still had reverse transcription mold activity, with combination rate up to 40 percent. This shows that the procedure reported in the article is quite satisfactory.

## III. cDNA second strand combination.

On the basis of the highly effective first strand combination, we adapted the carrier cloning (or direct cloning) method [5], using directly mRNA/cDNA hybridized double helixes as the substrate for second strand combination. The reaction system required the mediation of H-DNA polymerase I and the colibacillus derived DNA polymerase which depends on  $\beta$ -NAD. We studied the reaction condition with the following comparison:

1. Reaction system study. From Table 2 we can see that OAc<sup>-</sup> may be the key ion to enhancement of productivity. EtSH could have inhibitory effects on the reaction system. In our experiments we basically selected the conditions in I (see "materials and method").

2. The amount of RNaseH used. Since the amount of RNaseH used directly affects the number of cleavages on the hybridized double helixes, and this determines the effective starting point of DNA pol I in the combination of DNA. In order to obtain relatively stable amounts, we compared the effect of differing concentration on productivity (Figure 2). The conclusion is that in the 100  $\mu$ l reaction system, when the first strand cDNA content is higher to 3  $\mu$ g, then it is best to use 0.6 u RNaseH per  $\mu$ g of cDNA. With this concentration the second strand combination fragments can still be about 500 bp.

3. Applications of colibacillus DNA polymerase: The E. coli DNA polymerase which is dependent on  $\beta$ -NAD is different from T<sub>4</sub> DNA polymerase. Its main application is to connect cDNA second strand cleavages, and has lesser effects in the connecting of DNA and RNA and end fragments. Therefore, it is specially suitable for RNaseH and DNA polymerase I reaction system for the combination of cDNA second strand. However, since fragments of the second strands of cDNA do not affect the length of the entire cDNA strand, it is still possible to obtain effective cloning after strand end mending. Therefore, we have investigated the necessity of using polymerase.

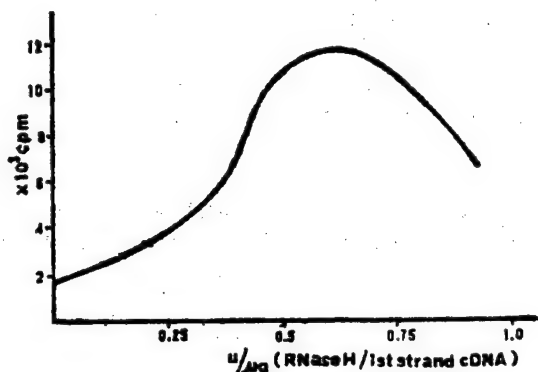


Figure 2. The effect of different concentrations of RNaseH on cDNA second strand productivity. (Tris-OAc buffer system)

In the most suitable conditions for RNaseH, if the reactants are kept at 14°C overnight, productivity increases by only 14.5 percent as compared to the original amount. However, if DNA polymerase is added to the system, the productivity increases by 89.6 percent as compared to that before adding the polymerase, thus increasing the rate of combination by about 100 percent. When we treated the products with electrophoresis, autoradiography showed that there was a significant increase in the length of strands. Therefore, this was different from that reported by Gubler et al [7]. We feel that if

DNA polymerase is added to the system, the production of second strands will be further increased.

In conclusion, the more favorable conditions for the separation of mRNA and combining cDNA from human lymphocytes are: (1) use GuTC/CsCl method to extract the entire store of RNA, and then use Oligo (dt) cellulose column to separate mRNA. This method is simple, saves time and is more reliable as compared to other methods. The separation and purification of mRNA can be completed within 2 days. (2) mRNA reverse transcriptase uses acetate system and is better than the Cl<sup>-</sup> system. Using reverse transcriptase at pH8.3, cDNA first strand combination can be as high as 70 percent. In general the level is higher than 50 percent. (3) cDNA second strand combination can employ RNaseH, DNA pol I and DNA polymerase reaction systems. The advantage of this method is that the combination rate is high; it is possible to rate 100 percent combination. In addition, this method saves the steps of alkalysis of mRNA and hydrolysis of S1 nucleinase. This not only saves time, it also guarantees large fragments combination and the completeness of the 5' end segment.

When the same conditions were used in the study of other mammal cells and malarious mRNA separation and cDNA combination also produced fairly satisfactory results.

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12996/7358

## LIPID PEROXIDATION, SUPEROXIDE DISMUTASE IN HUMAN ERYTHROCYTE

40081050a Beijing SHENGWUHUAXUE YU SHENGWUWULI JINZHAN [BIOCHEMISTRY AND BIOPHYSICS] in Chinese No 6, Dec 86 pp 35-36

[Article by Dong Wei [5516 0251], Li Xinjian [2621 2450 1696], Tao Guoshu [7118 0948 2873], Zhang Ling [1728 3781] of the Enzyme Institute of the Chinese Liberation Army Hospital Headquarters]

[Text] In recent years more and more research shows that free radicals have a part in many physiological and pathological processes [1]. Certain biochemical reactions triggered by free radicals bear important functions in the emergence and development of biological aging [2]. Therefore, in order to investigate the mechanism of human aging and obtain biochemical indicators of aging, we studied lipid peroxide values and amounts of superoxide free radical cation quenchers--superoxide dismutase (SOD) at different age-groups.

## Materials and Method

Subjects: These consisted of three groups of healthy subjects: 55 youths (18-35), 30 pre-seniors (50-59), and 37 longevity group members (90-96).

Methodology: Venous blood was obtained in the morning. The samples were centrifuged to remove the plasma. Red cells were eluted three times using saline-50mM Tris buffer (pH7.4). Red cell pellets were obtained.

Lipid peroxide assay: Uchlyma's method [3] was adapted for this study. Red cell pellets 0.5 ml was diluted, 1:1 in double-distilled water. To this hemolysed solution was added 0.42 ml ethanol-chloroform (5:3 v/v). The mixture was eluted for 1 minute in ice-bath. 0.16 ml of double-distilled water was then added. The mixture was centrifuged at 3000 rpm for 5 minutes. 0.5 ml of the supernatant was obtained, and to it was added 1.2 ml 20% acetic acid and 1.3 ml 1% thiobartituristic acid. The mixture was set in 95°C water for 1 hour. Then it was vibrated with iso-bulty alcohol for 1 minute for extraction. Then it was centrifuged at 3000 rpm for 10 minutes. The optical density of the extracted supernatant was determined at 532 nm wavelength. 1,1,3,3-tetra-ethyl propylene (TEP) was used as a standard. The results were expressed in terms of the propylene aldehyde (in nm) content per gram of hemoglobin protein content as measured by the sodium carbonate method.

SOD content determination: Misra's method [4] was used with slight alterations. 0.025ml of the abovementioned liquid samples were used. 1.0 ml of  $6 \times 10^{-4}$  M dianisidine and 1.0 ml of  $3.9 \times 10^{-5}$  M riboflavin were then added. The suspension was irradiated for 8 minutes under 40 watt fluorescent tubes at a distance of 3cm. The optical density was determined at 460 nm wavelength. TEP was used as the standard. The results were expressed in terms of  $\mu\text{g}$  of SOD per gram of hemoglobin protein.

## Results

1. Red cell lipid peroxidase content. Results are shown in table 1. Content in the pre-senior group is higher than the youth group, and in the longevity group, significantly higher than the pre-senior group.

Table 1. Red cell lipid peroxidase content of the various groups

Group	sample size	average age (years)	LPO (nm/gHb)	comparison with youth	
				t	P
youth	37	26.23 $\pm$ 0.86 (18-33)	2.61 $\pm$ 0.16	-	-
pre-senior	30	53.07 $\pm$ 0.41 (50-59)	3.09 $\pm$ 0.19	1.9199	<0.1
longevity	37	91.81 $\pm$ 0.29 (90-96)	3.59 $\pm$ 0.23	2.9461	<0.01

note: comparison of longevity and pre-senior group with  $p < 0.05$

Table 2. Content of red cell superoxide dismutase of the various groups

Group	sample size	average age (years)	SOD ( $\mu\text{g/gHb}$ )	comparison with youth	
				t	P
youth	55	25.05 $\pm$ 0.69 (18-35)	465.80 $\pm$ 11.72	-	-
pre-senior	29	53.24 $\pm$ 0.40 (50-59)	460.24 $\pm$ 10.89	0.3087	<0.8
longevity	37	91.81 $\pm$ 0.29 (90-96)	391.17 $\pm$ 29.15	2.7192	<0.01

note: comparison of longevity and pre-senior group with  $p < 0.05$

2. The red cell SOD content. The results are shown in table 2. The SOD value of the pre-senior group was slightly lower than that of the youth group. The SOD content of the longevity group was significantly lower than the youth group ( $p < 0.01$ ) and that of the pre-senior group ( $p < 0.05$ )

## Discussion

Commonly-occurring free radical in the body include superoxide free radical ( $O_2$ ), hydroxyl free radical ( $HO$ ), hydrogen peroxide free radical ( $HO_2$ ), and the like. These mainly are the products of normal or abnormal biochemical reactions in the organism. These radicals are very active in the body, and participate in a number of chain reactions to produce new free radicals, hence causing harmful effects to the organism.

The main area of harm of the free radicals to biological systems is the production of lipid superoxide [2]. The most important of these is propylene aldehyde. It can combine with protein, lipids, nucleic acids, and saccharides and cause membranes to denature, thus causing tissue damage and aging. When the organism is functioning normally, free radicals are produced continuously. However, they are removed continuously as well. However, the older human body does not contain as much anti-oxidase, and hence lipid superoxide content increases. It has been reported [5] that oxidation is the main cause of aging. The free radical and lipid superoxide content increase with age [6,7]. Our report shows that red cell lipid superoxide content increases with age, which is congruent with current literature.

The function of SOD is the catalyze of the dismutation of superoxide free radicals ( $O_2$ ). By eliminating free radicals, SOD can thus hinder the chain reactions of free radicals and protect the organism [8]. Therefore some researchers study SOD as an indicator of aging.

Research on the relationship of SOD and aging has been done mostly on experimental animals. Massie [9] discovered that in the C57BL/6J rat brain, the activity of SOD decreased by 32-36 percent as a function of age. Carrell [10] compared young and old rat liver SOD activity. The results showed that the latter group exhibited a 50 percent drop in activity. There have been fewer studies done on human SOD as it relates to aging. For experimental convenience, human studies were done by determining the SOD content of red cells. Recently, Wang Zanshun [11] reported that in 149 normal subjects the red cell SOD content showed a significant drop from the 20-39 years group to the 40-49 years group. This significant drop persisted till the age of 79. Micheleson [12] reported that in 200 normal subjects, the red cell SOD content of groups aged 60 or younger showed no significant differences (average value  $461.4 \pm 45.8 \mu\text{g/gHb}$ ), and the SOD value of 7 cases aged 60-69 ( $419.6 \pm 26.7 \mu\text{g/gHb}$ ), which is significantly lower than that of the youth group ( $463.3 \pm 51.6 \mu\text{g/gHb}$ ). The results from our report showed that the red cell SOD content of the pre-senior group is lower than the youth group, but not significantly so. On the other hand, the longevity group SOD values were significantly lower than the youth group ( $p < 0.01$ ) and the pre-seniors ( $p < 0.05$ ). The above results showed that the human red cell SOD content may begin decline at the pre-senior stage, and drops slowly with advancing age.

The red cell SOD values of the youth group were relatively high, and the lipid superoxide values were relatively low. In the longevity group the results were opposite. This may be because as age increases, the superoxide dismutase system that eliminates free radicals gradually diminishes, so that the poisonous matter collects as a result of the reactions of the free radicals and causes the human body to age with time.

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12996/7358

## METABOLISM OF FLUOROCARBONS STUDIED

40081004 Tianjin ZHONGHUA XUEYEXUE ZAZHI [CHINESE JOURNAL OF HEMATOLOGY] in Chinese Vol 7, No 8, 30 Aug 86 pp 459-461

[Article by Ding Shuncheng [0002 6064 6134], Zhang Shengnian [1728 0524 1628], Chen Binwu [7115 1755 2976] and Liu Chunfang [0491, 2504, 5364], Shanghai Institute of Labor Hygiene and Occupational Diseases; Zhang Yusheng [4545 3022 5116] and Zhang Shen'an [4545 3947 1344], Shanghai Medical Industry Research Institute; and Cao Wenjuan [2580, 2429, 122] and Luo Changping [7482 2490 1627], Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences: "The Metabolism in Vivo of Fluorocarbon Blood Substitute"]

[Text] Abstract: Following injection of fluorocarbon emulsion [FCE] into the coccygeal vein of a rat, the FCE content of the liver was found to be at a maximum on the first day. The curve for the time it took for the drug to disappear was figured according to the Second Office [sic] open model mathematical formula, the drug metabolism dynamic parameters for the disappearance of the FCE from the liver being  $T_{1/2}(\alpha) = 2.8$  days,  $T_{1/2}(\beta) = 60$  days, and  $C = 32.49e^{-0.2452t} + 6.41e^{-0.0114t}$ . In addition, the components FTPA and FDC of the perfluorocarbon compound in the FCE gradually disappeared from the liver and spleen at a definite rate over time. The FDC/FTPA value was less than 1 beginning from the twenty-first day after the injection in the case of the liver, and beginning from the forty-second day after the injection in the case of the spleen. This showed the in vivo disappearance to be faster for the FDC than for the FTPA. A GC/MS analysis of the FDC and the FTPA in the liver showed the two as having undergone no changes in their make up, so presumably the FCE was biologically inert.

Clarification of the process whereby fluorocarbon blood substitutes (fluorocarbon emulsions, FCE) are metabolized in vivo and the physiological activity of the products of metabolism are of reference value in setting limits for general medicinal use, as well as for changes in the make up of FCE components. This article describes the use of gaseous phase chromatographic quantitative analysis and of a combination of gaseous phase chromatography and mass spectrum techniques to study in vivo metabolic changes in mice and rats.



## Materials and Methods

### 1. Fluorocarbon Emulsions

Perfluorocarbon compounds, including 99 percent pure perfluoro-decahydronaphthalene (FDC) and 96 percent pure perfluoro-tripropyl amine (FTPA) synthesized by the Shanghai Institute of Organic Chemistry of the Chinese Academy of Sciences were used. These were emulsified by the Pharmacy Department of the Zhongshan Hospital in Shanghai. The tested value of fluorocarbon content was 20 g/100 ml, with 96 percent of fluorocarbon particles being larger than 0.2  $\mu\text{m}$ , those with a diameter greater than 0.1  $\mu\text{m}$  numbering between 35 and 40 percent, and those with a diameter of between 0.3 and 0.4  $\mu\text{m}$  numbering 4 percent. Maximum diameter of particles was 0.4  $\mu\text{m}$ . Quality was consistent with requirements for clinical use.

### 2. Method of Administering and Dosage for Animals

Thirty-six Wistar rats were divided into 12 groups and injected in the celiac vein with 36 ml/kg of FCE. On days 1, 2, 3, 5, 7, 14, 21, 28, 42 and 56 following inoculation, they were decapitated and their livers and spleens removed for measurement of the FCE content. Sixteen ICR mice were divided into two groups and 50ml/kg of FCE was injected into their celiac veins. A saline solution was injected into the celiac veins of a control group of mice. The two groups given the FCE injection were decapitated 24 and 72 hours respectively following injection, and GC/MS was used to analyze metabolic changes in the FCE in their livers and spleens.

3. Measurement of FCE content in the biological tissue as well as GC/MS analysis were done using the method described in Reference 1 at the end of this article. A tissue paste was prepared using trifluorotrichloroethane to extract the FCE. A Model 102 gaseous phase chromatograph and a hydrogen flame ionization test device was used for the quantitative analysis of the amount of FCE, the degree of sensitivity being 0.01  $\mu\text{g/g}$  wet weight.

A Varian MAT Model 212 Mass spectrophotograph and an SSMAT Model 188 data processing system were used to analyze metabolic changes in the FDC and the FTPA in the liver. A 40M SE-52 glass capillary tube column with a column temperature of 40 degrees centigrade and a gasification temperature of 150 degrees centigrade, a helium (He) gas carrier of 0.8 kg/sq cm, an EI flow of 70cV of electron energy and emitting 1mA of current, a separator and an ion source with a temperature of 200 degrees C were used. The amount of specimen put in was F113 and 1.0  $\mu\text{l}$  of fluid was extracted.

## Results

Dynamic changes in the FDC and FTPA content of the liver were as follows:

Table 1 shows the greatest amount of FDC and FTPA as having been removed from the liver on the first day, the wet weight of the two drugs totaling 38.90 plus or minus 10 mg/g, the wet weight of the FDC and the FTPA respectively being 30.4 plus or minus 10 mg/g and 8.5 plus or minus 0.4 mg/g.

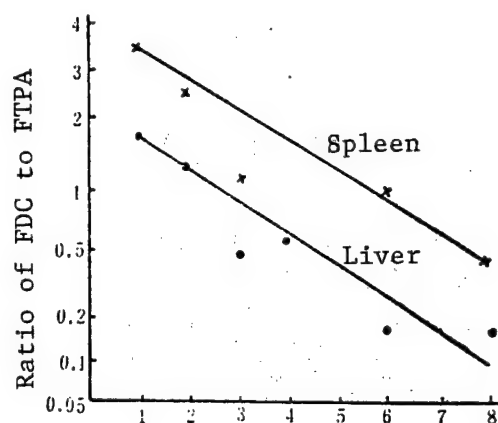
The FCE content of the liver gradually decreased with time until the 56th day when it was only approximately one-seventh of what it had been on the first day. The speed of disappearance for all parameters analyzed using the open model mathematics formula of the Drug Metabolism Dynamics Office Number 2 was as follows:  $K_{10} = 0.0218$ ,  $K_{12} = 0.1065$ ,  $K_{21} = 0.1283$ ,  $A = 32.49\text{mg/g}$ ,  $B = 6.41\text{ mg/g}$ ,  $\alpha = 0.2452/\text{day}$ ,  $\beta = 0.0114/\text{day}$ ,  $t_{1/2}(\alpha) = 2.8\text{ day}$ ,  $t_{1/2}(\beta) = 60.6\text{ day}$ ,  $C = 32.49e^{-0.2452t} + 6.41e^{-0.0114t}$ . The half reduction time for FCE in the liver was 64 days.

Table 1. FDC and FTPA Content of the Liver of Rats Following Injection With FCE

Days Following Inoculation	FCE Content of Liver, mg/g Wet Weight		
	FDC	FTPA	Total Amount
0.02	1.74±0.15	0.51±0.8	2.25±0.23
9.25	17.86±3.0	3.94±0.5	21.61±5.6
1	30.40±10	8.50±0.4	38.90±10
2	26.67± 5	8.23±0.8	34.90± 6
3	13.92± 3	4.68±0.3	18.60± 4
5	24.0 ± 3	2.60±0.4	26.60± 6
7	12.0 ± 4	7.0 ± 2	19.0 ± 7
14	8.07±1.8	6.43± 2	14.5 ±2.1
21	1.04±0.2	2.26±0.3	3.30±0.5
28	0.60±0.3	1.10±0.2	1.70±0.3
42	0.69±0.1	3.71±0.3	4.4 ±0.4
56	0.90±0.1	3.70±0.3	4.6 ±0.3

## 2. Speed of Disappearance From the Liver and Spleen of FDC and FTPA:

Figure 1 shows a definite slope decline in FDC and FTPA over time. Beginning from the twenty-first day, the FDC and FTPA in the liver went from greater than 1 to less than 1, though it took until the forty-second day for a reversal in the proportion in the spleen. These results show a more rapid rate of elimination for the FDC, and that the FTPA lingered in the tissues for longer than the FDC, the amount of drug in the spleen being almost twice again as much as in the liver.



No. of Weeks Following FCE Inoculation of Rats

Figure 1. Rate of Disappearance of FDC and FTPA From the Liver and Spleen

### 3. Biological Inertness of FDC and FTPA in the Liver

In order to determine whether the FDC and FTPA were metabolically changed in the liver and to evaluate the metabolized compounds, the mice were given an injection of 50 ml/kg of FCE in their codygeal vein, and their livers were removed 72 hours later for GC/MS analysis. The results showed peaks of m/e 69, 100, 169, 241, 314 and 402 for FTPA in the liver on the electronic impact mass spectogram. The electronic impact mass spectogram for Trans-FDC and Cis-FDC in the liver showed respective peaks at m/e 69, 93, 131, 181, 243, 293, and 443, and at 69, 131, 169, 243, 293, and 443. These were the same as for standard grade electronic impact mass spectograms except for a slight change in the relative strengths of certain m/e such as 131, 293 and 343.

In order to clarify these results even more, the qualitative chromatographs for standard samples containing a mixture of FDC and FTPA were compared with those for the FDC and the FTPA in the liver. The characteristic ions compared were m/e 131, 243, 293, 343, 393, 443, and 462 (FDC), and m/e 69, 100, 169, 214, 264, 314, and 402 (FTPA). Figure 2 shows no change in the characteristic peaks for external standard samples and specimens from within the liver. In addition, the total ion flow chart for GC/MS in the fluid extracted from the liver tissue was compared with the total ion flow chart for GC/MS in the external specimen. A fairly large peak occurred at the impurity peak position for the original FTPA, but at the peaking position for the FTPA, a peak smaller than that for the standard sample FTPA appeared. In view of these circumstances, these two samples were redone in the gaseous phase chromatograph containing a hydrogen flame testing device from which observation of the delay time showed the same results.

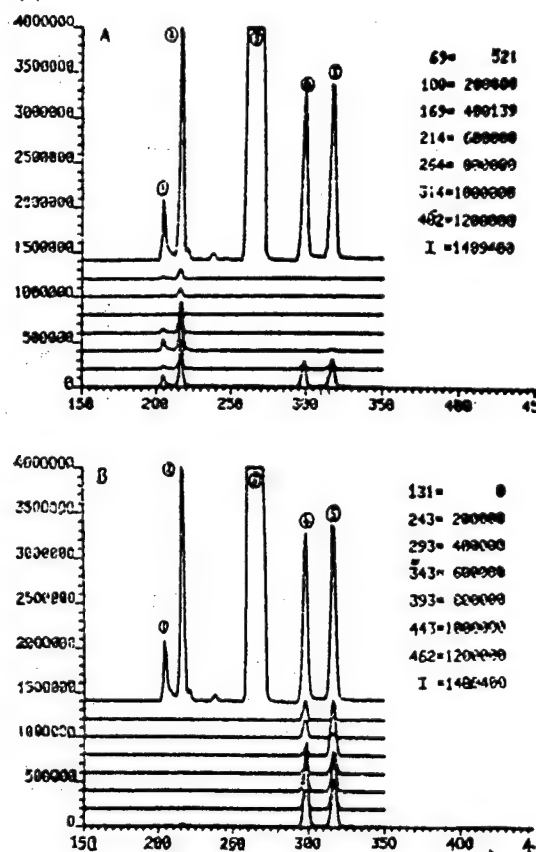


Figure 2. Quality Chromatogram For FTPA (Above) and FDC (Below) in the Liver and For Standard Samples (1) FTPA (2) Impurities in FTPA (3) F<sub>113</sub> (4) Cis-FDC (5) Trans-FDC.

### Discussion

In 1982, Kitazawa and Ohnishi reported that after injecting 67 ml/kg of Fluosol-DA into a rabbit in 2 days, the reticulated endothelial system of the liver and spleen still harbored large amounts of fluorocarbon compounds 1 year later.<sup>2</sup> In this experiment, after 36 ml/kg of FCE were injected into the rats, the half reduction time for FCE in the liver was 63.4 days, and it disappeared from the body fairly slowly. In 1978, Yokoyama pointed out that FDC and FTPA disappear from the body at different rates.<sup>3</sup> The results of our experiments show the rate of disappearance from the liver and spleen of FDC to be faster than for FTPA, the FTPA remaining in the tissues for a longer time. Moore et al believed there was a definite correlation between the speed with which fluorocarbons were eliminated and their critical consolute temperature (CST). The greater their solubility among the fatty hydrocarbons, the easier for them to pass through cell membranes and be eliminated.<sup>4</sup> The CST for FDC is 19.7, but the CST for FTPA is 42.9, showing that the latter lingers longer in the body. To summarize the foregoing, it takes a long time to eliminate entirely both FDC and FTPA from the body, and the repeated use of drugs within a short period of time may produce an accumulation; thus, the amounts have to be reduced when the drugs are repeated in clinical use.

Results from the use of GC/MS techniques and the analysis of the FDC and FTPA to see whether metabolic changes in them had occurred in the rats' livers showed no metabolic changes as having taken place in the livers. This was entirely consistent with Yokoyama's findings.<sup>5</sup> It has been demonstrated that FCE acts as a foreign body entering the body. When too many fluorocarbon particle mononuclear microphage cells are ingested, some degeneration may occur in the formation of cell DNA and bone marrow; however, the form of most cells remains normal. No protracted changes in major organ function have been observed.<sup>6</sup>[sic] Some researchers have discovered fibrosis of rabbit liver connective tissue,<sup>2</sup> but such was not observed in our experiments. The reason awaits further study.

On the basis of the CG/M total ion flow charge for fluid extracted from liver tissue after 72 hours in which the appearance of a fairly large peak at the position where the FTPA contained impurities was discovered, we conclude from a look at the spectrum retention time that there existed no new fluoride compounds. This may be the reason why the FTPA impurities penetrated the cell membrane to enter the liver faster than the FTPA.

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(Draft received 2 February 1985; revised and returned on 23 May 1985)

9432/7358

HISTORY, TRENDS OF PROTEIN ENGINEERING DISCUSSED

40091006 Shanghai ZIRAN ZAZHI [NATURE JOURNAL] in Chinese Vol 10 No 4, Apr 87  
pp 246-251

[Article by Wu Ming [0702 2494] of the Institute of Microbiology, Chinese Academy of Sciences]

[Abstract] As the adviser for the thesis of Dr. F. Crick, who formulated the DNA double helix model, M. Perutz of the Cambridge Molecular Biology Institute, United Kingdom, pioneered the research and exploited the potential of protein engineering. In 1962, Crick was awarded a Nobel Prize in Chemistry due to his contribution to research on the structure of hemoglobin. The paper then analyzes the relationship between structure and function of an enzyme molecule, as well as techniques of site-directed mutagenesis. In 1981, for the first time, K. Ulmer of the Genen Corporation (United States) referred to this technique as protein engineering. As a well-publicized product of genetic engineering, interferon is very unstable when heated and can be stored only for a very short time, even at the low temperature of  $-70^{\circ}\text{C}$ . In another product, a commercially-available human growth hormone produces enough antibodies to induce immunity in the human body. Improvements are needed to move these products and other proteins from the laboratory into the marketplace. Therefore, three-dimensional structures of these proteins need to be described, and the position of key amino acids affecting these properties need to be located. The technique of site-directed mutagenesis comes into play. Generally speaking, protein engineering is an important stage of the more general molecular engineering for building entirely new molecules (not found in nature) atom by atom.

One table lists commercially-available products of genetic engineering. Three figures show a DNA mutation of  $\phi\text{X174}$  bacteriophage, site-directed mutagenesis for position 587 of DNA in the  $\phi\text{X174}$  bacteriophage, and the three-dimensional structure of tyrosyl-tRNA synthetase.

10424

PLANT RNA VIRUSES AS GENE ENGINEERING VECTOR SYSTEMS DISCUSSED

40091006 Shanghai ZIRAN ZAZHI [NATURE JOURNAL] in Chinese Vol 10 No 4, Apr 87  
pp 323-328

[Article by Miao Gang [4924 0474] and Wang Mingqi [3769 7686 1477] of Fudan University]

[Abstract] In 1984, for the first time, the Paul Ahlquist research team obtained gene groups of plant virus RNA exhibiting active infectivity from an in vitro re-recording system of clones. The following year the team made a major breakthrough: the vector system of bromegrass mosaic virus (BMV) of a plant RNA virus was successfully expressed in barley (a monocotyledon species) protoplast in the bacterial gene of the chloromycetin acetaldehyde transfer enzyme (CAT). At present in China and abroad, research using the plant RNA virus as a vector system is underway in the four following directions: 1. research on molecular biology involving plant RNA virus, 2. cloning of gene groups of the virus, 3. sequential insertion of an external-source gene into the virus gene and 4. mono-cellular protoplasm expressed in the entire plant. Therefore, new desirable properties can be introduced into a plant to make it more useful to man and for its own survival. This enhanced quality of a plant can be passed down to its progeny in accordance with the Mendelian inheritance and some other modalities in a stable heredity. Three figures show the reconstruction of the gene RNA of BMV, first-level structure of BMV gene RNA3 and an in vitro re-recording templet using EcoR I to excise from pB<sub>1</sub>pM<sub>18</sub>, pB<sub>2</sub>pM<sub>25</sub> and pB<sub>3</sub>pM<sub>1</sub>. The authors are grateful to Professor Albert Kester at the University of Wisconsin for providing data, and to Yu Shanqian [0060 0810 6197], an associate professor at Fudan University, for his advice.

10424

HUMAN-ANIMAL COMMON PATHOGENS BECOMING INCREASING PUBLIC HEALTH CONCERN

40082019c Beijing KEJI RIBAO in Chinese 16 Jun 87 p 1

[Text] Reporter Yang Jing reports that the Committee on Human-Animal Common Pathogens of the Chinese Microbiological Institute conducted a conference from 4 to 9 June in Tunxi County, Anhui Province. More than 40 representatives were present at the conference. They exchanged up-to-date developments in the research and prevention of human-animal common pathogens in China and overseas. They also studied in-depth the research direction on human-animal common pathogens in China. Representatives at the conference unanimously agreed that it was time to further research macro-ecological factors affecting human-animal common pathogens. At the same time, it was necessary to study the micro-ecological factors, so that China can advance into the forefront in the world.

Human-animal common pathogens are known internationally as animal pathogens. It stands for the natural contagions between humans and vertebrates. In other words, it represents that which is caused by pathogens common to both humans and vertebrates. In epidemiological terms, they are related diseases.

These diseases are caused by many micro-organisms, such as bacteria, fungus, spirochetes, mycoplasmas, chlamydia, rickettsia, viruses, and parasites. Currently, more than 100 diseases fall into this category. Most of these diseases, rabies, for example, are transmitted from animals to humans. Human-animal common diseases not only pose a major threat to human health, they can also lead to pandemics in livestock, causing them to die en masse, resulting in great economic losses. With the development of foreign trade and specialization of agriculture, human-animal common diseases are becoming an increasing public health concern.

Representatives at the conference argued that diseases spread to humans from animals are more difficult to control and eradicate than diseases of non-animal origin, and require long-term, continuous, and comprehensive prevention. It is specially important to redouble efforts in prevention in the ecological realm to achieve the maximum efficiency.

It is a characteristic of human-animal common pathogens that they require the cooperative efforts of physicians and veterinarians, because this is more



effective than just having physicians treating human diseases, and veterinarians treating animal diseases.

With serious human-animal common diseases, such as diarrhia, rabies, plague, brucellosis, psittacosis, trematodiasis, and anthrax, experts suggest that the leadership of the departments establish more effective preventive policies. Also, newly diagnosed human-animal common diseases such as AIDS should be studied in depth.

12996/7358

## PRELIMINARY STUDY ON PREPARATION OF MONOCLONAL ANTIBODIES

40082019a Beijing ZHONGHUA WEISHENGWUXUE HE MIANYIXUE ZAZHI [CHINESE JOURNAL OF MICROBIOLOGY AND IMMUNOLOGY] in Chinese Vol 7, No 2, Apr 87 p 114

[Article by Wang Dakun [3769 1129 0981], Feng Jiangnan [1409 3068 0589], Sun Kefang [1327 0668 5364], Yu Jian [0060 4628] and Shi Liangru [0670 5328 1172] of the Ministry of Public Health Wuhan Biologicals Institute]

[Text] In the preparation of monoclonal antibodies, the standard immunological method is secondary basal immunization plus primary venous reinforcement (commonly known as standard method). The disadvantages of this method include the need for a lengthy immunization period, and large amounts of antigens. Spitz and others have recently introduced an immunological method of opening up the abdomen and directly injecting single dose antigens into the spleen (intrasplenic method in short), and obtained satisfactory results. This method requires very little immunization time (88 hours), and the amount of antigen needed is low (cellular antigen at 300,000 units, or soluble antigen at 20 $\mu$ g - 100 $\mu$ g).

We used cells from fetal thymus glands as antigen to investigate the intrasplenic immunological method. In using the intrasplenic method, we compared a secondary basal immunological intrasplenic reinforcement method with the standard method. The results showed that the rate of formation of hybridized tumors in the intrasplenic method (99 percent) was higher than the standard method (66 percent). Preliminary results from the use of fetal thymal cells and some T-cells showed that the rate of formation of specific anti-T-cell hybridization tumors was lower in the intrasplenic method (33 percent) in comparison to secondary basal immunological intrasplenic reinforcement method (83 percent), and the standard method (81 percent). Therefore, we tentatively conclude that the intrasplenic method is probably not suitable with the use of complicated cellular antigens but more suitable with simple cellular antigens or soluble antigens. Furthermore, the reasons for the low rate of formation of specific hybridization tumor in the intrasplenic method requires further study.

12996/7358

## BREAKTHROUGH IN ALGA-FERN RECOMBINATION RESEARCH REPORTED

40082019b Beijing KEJI RIBAO in Chinese 11 Jun 87 p 1

[Text] There has been an important advance recently in research in the recombination of alga-fern. Experts believe that this is a major breakthrough in agricultural technology, and rank it at the international level.

Alga-fern is an important source of nitrogenous fertilizer. Rotating alga-fern with wheat provides the fields not only with good fertilizer, but also good feed as well. Alga-fern is a symbiotic nitrogen-fixing system consisting of fern and alga. In order to fully develop the nitrogen-fixing potential of alga-fern, and to fully understand the symbiotic relationship between the fern and the alga, scientists at home and abroad have conducted a great amount of research in the last 10 years. Today, the fern and the alga in the symbiotic system can be successfully separated and cultivated. However, the recombination of a new symbiotic system of the alga with the fern has not yet been reported. Many experts in the world feel that this recombination is very difficult to accomplish.

Researcher Liu Zhongzhu [0491 0022 2691] and Doctor Lin Cang [2651 3318] of the Fujian Agricultural Institute have conducted research on this topic since 1978. Also, in 1980, they succeeded in the recombination of the alga and the fern from the same sample.

In the last few years, in order to obtain recombinations from different samples and stronger verification techniques, they concentrated on monoclonal antibody studies on the alga, and were successful in that endeavor. During the time when Lin Cang was studying for his doctorate at the International Wheat Research Center, he performed in-depth investigations in the fertilization during the sporocarp stage of the fern. Based on this research, he was able to cultivate normal growing ferns from their sporocarps. Then, they finished the task of recombining algae and ferns from the same sample as well as from different samples. The newly recombined alga-fern was shown to be a recombined system when assayed by monoclonal antibodies, determined by nitrogen-fixing enzymes and tracked by EKG. This recombined alga-fern, in addition to its nitrogen-fixing property and normal growth, also exhibits some new and favorable characteristics. For example, the small green alga which is not tolerant of heat can grow normally in daily average temperature around 33°C when added to the heat-tolerant alga. The successful recombination of the alga-fern has provided strong proof for the theoretical

understanding of the symbiotic relationship of the alga and the fern, especially that of the establishment of the symbiotic relationship. As to the prospects of the use of the alga-fern, the successful recombination of alga-fern has opened up a new way in cultivating alga-fern. In selecting ideal samples of fern, alga, and methods of recombination, improved new samples of alga-fern can be obtained. Up to now, the samples of alga-fern used in agricultural production all come from natural sources. The recombination of alga-fern will allow the existing technology in the cultivation, experimental improvements, and utilization of alga-fern to reap unestimable benefits.

12996/7358

## BRIEFS

ANTI-CANCER HERBS--Suineng County in Hunan Province has cultivated more than 53,000 anti-cancer Chinese Jiaogulan medicinal herbs. Jiaogulan belongs to the Cucurbitaceae family. It is a perennial herbaceous vine, and contains more than 50 alkaline glycosides, and is known as "southerner's ginseng." It can lower blood lipids, cure bronchitis, gastric ulcer, and diabetes, enhance the appetite, promote sleep, and provide defense against fatigue, aging, and cancer. Many developed countries have studied this plant for a number of years. In Japan, Jiaogulan is a fad. China's State Science and Technology Commission has listed Jiaogulan in the "spark plan." In China, research on the production and application of Jiaogulan is starting to accelerate and research on the extraction process and the production formula of the Jiaogulan alkaline glycoside by the Hunan Chinese Herbal Medicine Institute has produced preliminary results. [Text] [40082019d Beijing REMIN RIBAO in Chinese 3 Jul 87 p 3] 12996/7358

LEGISLATION PROPOSED REGARDING CONTROL OF SCIENCE ACHIEVEMENTS

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF S&T] in Chinese No 8, Aug 87, pp 44-45

[Article by Zeng Liuquan [2582 2692 2938], Guangzhou Municipal Science and Technology Committee: "Using Legal Methods To Manage Science and Technology Results"]

[Text] What is commonly referred to as management of scientific and technological achievements generally consists of the links of appraisal, registration (including public announcement and dissent), creating a file, petitions, prizes, maintaining security, exchanges and promotion. In February 1984, the State Science and Technology Commission's "Stipulations On Management of Scientific and Technical Achievements" made some stipulations articulating principles concerning management of the above links. However, with the establishment of China's patent system and since the implementation of Patent Law on 1 April 1985, many new situations and new problems have appeared and society's calls for an early resolution of these new problems has become more strident. This writer feels that researching these new situations and resolving these new problems must first proceed from fundamental stress on legislative (including administrative legislative) work in management of scientific and technical achievements and applying the law and legal methods to readjust these relationships. I propose that we begin with the following areas:

Scientific and Technological Achievement Appraisal and Legislation

"The General Rules on Civil Law of the People's Republic of China" protect scientific and technological achievement rights as intellectual property rights. The legal position which they enjoy is uniquely Chinese, but the definition and determination of scientific and technological achievements lacks any concept in law. In fact, "originality" (i.e., creativity) frequently is misinterpreted as "regional originality" and even though it exists in other provinces and localities it can be termed "originated in the province" or "originated in the city" and this is contrary to the definition of China's "Patent Law". If through establishing scientific and technological achievement laws we can clarify what a scientific and technological achievement is and how to acknowledge scientific and technological achievements, for example, convening a technical appraisal meeting after acknowledging a scientific and technological achievement through a check of

international agencies or renewal of patent documents then these "we have what they have" results can be suppressed at the first condition check and thus greatly reduce the incidence of "simplified appraisal", technological breakthrough appraisal" and "formalization".

Achievement appraisal is generally by group evaluation or written evaluation (i.e., the communication review method). Written evaluation is generally directed by the department that issued the order or the industrial unit responsible. Those participating in written evaluation were considered, were not affected by the situation, evaluations were objective and were very frugal, and the achievement appraisal law should first of all contain this method. The scientific and technological achievement appraisal law should also include such conditions as appraisal goals, scope, appraisal form, demands, procedures, achievement rights jurisdiction (primary completion unit and primary completers), the appraisers' responsibility and compensation, and responsibility of control, inspection, and management departments especially should be clarified. Inspection departments (units) frequently have dual tasks of inspection and scientific research and those who use their authority and professional status to steal or share the achievements of others should be investigated to protect the technical rights of the unit being checked.

#### Scientific and Technological Achievement Awards and Legislation

Awards for scientific and technological achievement in China are currently carried out in accord with the four award conditions approved by the State Council and the law passed by the National People's Congress, i.e., the awards sections of "Terms [sic] for Natural Sciences Awards", "Articles on Invention Awards", "Articles on Science and Technology Advance Awards", "Articles on Rationalized Proposals and Technological Reform Awards", and "Patent Law". The "Four Awards and One Law" has played an important role in mobilizing the initiative and creativity of the masses of science and technology workers and the worker and peasant masses and promoting the progress of science and technology. However, the relationship between science and technology awards and the patent system is complex. For example, there are differences in such areas as the scope of the award objectives, award conditions, rank of award authoritativeness, application procedures, application documents, whether or not applications must be unique, procedures for objections, whether or not there are application fees, examiners, approval agencies, approval procedures, application regions, jurisdiction of rights, legal effectiveness, time limits on achievement rights, degree of public means, whether or not there are application principles and first invention principles, and the meaning of creativity. This introduces a variety of complications for those giving the award and units requesting it. These relationships should be readjusted through establishing a "Scientific and Technological Award Law" and other administrative laws. A "Scientific and Technological Award Law" should include at least the following:

##### 1. The Readjustment Object of the Scientific and Technological Award Law:

The Scientific and Technological Award Law is to readjust the relationships between the ownership rights of discovery and invention and the use of inventions and discoveries in production.

It reduces the "Articles on Natural Sciences Awards" and "Articles on Awards for Inventions" to a single legal document which is equivalent to the "Patent Law".

## 2. Award Conditions:

The award demands for natural science prizes can still abide by the original standard demands, i.e., that it be a scientific research achievement which explains a natural phenomenon, peculiarity or law which has importance in science and technology development.

The "originality" (creativity) and "advanced nature" in the article on invention awards still basically is in accord with the original standard demands but there are further demands on "creativity", i.e., the demand that it be the first in the world and that it be termed absolutely unique in the world in order to improve the prestige of China's awards internationally and manifest the principle of comparability of inventive creativity. The demand of "practicality" generally demands that it be for obvious economic and social benefits, but also should consider the situation that if some inventing units apply the invention only for social benefits and the unit's economic benefits are very small or not anticipated then it lacks the initiative to apply the invention and such a situation should be analyzed concretely and treated separately.

Concerning national level advanced science and technology awards readjusted using administrative methods, they should be "domestic originality" (exploratory), i.e., relative originality, "advanced nature" and "practicality".

## Scientific and Technological Achievement Security and Legislation

Before China implemented the patent system, state approved inventions could become invention stage achievements and although they existed abroad, like other important scientific and technological achievements, they were within the range of China's science and technology security. After implementing the patent system, a number of new problems and situation appeared, patent descriptions were public information and generally if one wanted to obtain patent rights, the content had to be made public. Before the patent system was implemented, before an inventive technology could be licensed or sold abroad, either through foreign economic assistance or international scientific and technological cooperation, it had to be investigated by the ministries, committees and bureaus of the State Council or the provincial, municipal and autonomous region science and technology committees and reported to the State Science and Technology Commission for approval. After the patent system was implemented, the China Patent Office determined whether or not a patented technology was a secret patent. Before it had to be investigated and checked at each level but now the inventor himself or his agent directly sends (mails) invention petition for a patent to the State Patent Office for security check so the size of the leap is very large. A dual track system is now in place for management of scientific and technological achievement security: one is scientific and technological security inspection and management from the



central government to the local science and technology management departments; the other is the inspection and management by the State Patent Bureau of proposals for inclusion as a secret patent. Due to the needs of the developing situation, the existing "Science and Technology Security Articles" which were announced by the State Council in 1981 as administrative regulations should be raised to the status of legal documents, i.e., formulated as "Science and Technology Security Law". The legislation should make it clear that the national science and technology security work is under the unified management of the State Science and Technology Commission or the joint management of the State Science and Technology Commission and the State Patent Bureau, changing the "dual track system" into a "single track system." At the same time the science and technology security law should have such provisions as security scope, classification levels, use of materials at various classification levels, jurisdiction of classification levels, declassification, lowering classification, raising classification, management concerning foreign affairs, security obligations, disposition of security organizations and agencies and their responsibilities and jurisdictions and corresponding title (job) system.

#### Scientific and Technological Achievement Promotion and Legislation

The economic benefits produced by the promotion and application of scientific and technological achievements generally grow several fold compared with the original holding unit. While implementing the principle of compensated technology use and maintaining competition the state should implement legislation to promote scientific and technological achievements. The legislation should obey the following principles:

1. Feasibility principle: i.e., the principle of analyzing the feasibility in terms of technology, economics, policy and law and verifying the correct benefits of production after it is promoted.
2. Optimal investment principle: selecting those projects which can bring fundamental change to the industry or can serve multiple industries and produce obvious benefits for key investment and promotion.
3. Impetus principle: accelerating the promotion of scientific and technological achievements in such areas as loan policy, taxation policy, pricing policy and resource allocation policy.
4. Compulsory permission principle: i.e., the principle of including achievements which are decisive to national economic development in directive type promotion plans.
5. Compensation principle: under ordinary circumstances, enterprises are not willing to establish a competitor to themselves. However, some achievements whose promotion will produce greater social benefits must be promoted and this is a pair of contradictions. To resolve this contradiction, the state should establish a special purchasing fund to compensate the purchasing unit for economic losses and a smaller market as a result of the establishment of a competitor in order to encourage purchasing units to accelerate their technological pace, open up new areas and create more new achievements.

6. Overlapping permission principle: in the promotion process new achievements are also produced so the promotion unit and the original unit should have overlapping permission technologically so that each can utilize the other's technology.

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PROGRESS IN STUDY OF RADIOTOXICOLOGY OUTLINED

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[Text] Study of radiotoxicology in China began in 1958. In response to the need to shield against radiation regarding the use of atomic energy, several highly toxic (approximately 17) nucleides were systematically compared in the study. It included experimental research, observation of the effect on humans and epidemiology survey. The study of the hazard and prevention of radioactive fallout, the study of radon induced lung cancer and its early treatment, the comparative toxicology study of radioactive iodine, the toxicity of uranium and thorium and an evaluation of the health of the workers in the field, the genetic effect of tritium, the experimental research on tumors induced by plutonium and other elements beyond plutonium, and the research on drugs which accelerate the discharge of radioactive nuclides have made a significant contribution to the application of nuclear energy.

This paper describes the progress in radiotoxicology from the metabolism and effect of radioactive nuclides, and the study of drugs which accelerate their removal.

Study of Metabolic Mechanisms of Radioactive Nuclides

This is a fundamental subject in radiotoxicology. It is the foundation for analyzing the damage induced by radioactive nuclides and is used as the basis in estimating the amount of contamination and the internal dose level. A review of this field shows that significant progress has been made in the following three areas:

1. Target Locations of Radioactive Nuclides Ascertained

Among the 10 or so nuclides studied, with the exception of tritium and cesium which are more or less uniformly distributed, other nuclides are selectively distributed (both macroscopically and microscopically). Aqueous solutions of

early fallout contain iodine, molybdenum, tellurium, strontium, barium and rare earth nuclides. It is especially important to ascertain their target locations in this kind of mixture. Experiments performed in this laboratory with rats and dogs showed that  $^{131}\text{I}$ ,  $^{132}\text{I}$  and  $^{133}\text{I}$  absorbed from the digestive track primarily deposited in the thyroid,  $^{89}\text{Sr}$  and  $^{140}\text{Ba}$  mainly in the bones, and  $^{99}\text{Mo}$  in the liver. Because more iodine nuclides are produced in the fission process, several months after they enter the body, the activity in the thyroid is significantly higher than that in the bones or liver. Therefore, the thyroid is the major target in the early stage. Continuous sectioning was employed to observe the detailed distribution in the thyroid. The activity in the center was found to be higher than the periphery. Autoradiography showed that iodine is first deposited at the epithelial cell and then concentrated in the follicle. This evidence indicates that the epithelial cell is the primary target of iodine nuclides.

$^{147}\text{Pm}$  is widely used as the excitation source in luminescent powder. It is also unevenly distributed in the body. From the studies done by Li Mingjun [2621 2494 0689] [1] and Zhu Shoupeng [2621 1108 1756] [2] on the distribution of  $^{147}\text{Pm}$ , it is primarily deposited in the liver, spleen and bones. In the late stage, it is mainly stored in the bones. Initially, it is deposited in the epiphyseal plate and cartilage. Then, it is concentrated at the porous area. In the hip bone, it is distributed at the periosteum. The selective deposition of  $^{147}\text{Pm}$  in the bones and its distribution characteristics serve as important references in interpreting injury characteristics.

Chen Songru [7115 1172 2646] [3] studied the detailed distribution of  $^{239}\text{Pu}$  in the testicle. It was observed that  $^{239}\text{Pu}$  is primarily distributed in the interstitial cells. A trace of plutonium was also found in the spermatocyte at the outer layer of the spermiduct. The male hormone is synthesized at the interstitial cell and the spermatocyte is the parent cell of the sperm. Based on the mean diameter of the spermiduct and the plutonium distribution percentage, it was estimated that spermatocyte dose was six times higher than that of the average testicle tissue. This result is significant in ascertaining the target cells and in analyzing possible damage due to the irradiation of the testicle.

Li Suyuan [2621 4790 0061] [4] proved that the distribution of short-lived radon  $\text{RaA}$ ,  $\text{RaC}$  and  $\text{RaC'}$  varies significantly in the respiratory tract in rabbits. Based on the measured specific activities at the trachea, bronchus, edge of a lobe of the lung, remaining portion of the lung and average value of the lung, as well as the measured pathological parameters, the absorption dose per patent energy of the irradiation is estimated. The dose at the base cell of the new bronchus is the highest. It is 12 and 8 times higher than the doses at the edge of a lobe and of the entire lung, respectively. This indicates that basal bronchus cells are the target cells for radon induced cancer.

## 2. Metabolic Kinetics of Nuclides in the Body

The nuclides are continuously transferred and removed from the body with time, creating a kinetic process. Our laboratory observed the dynamic changes in

thyroid and urine activities after ingestion of exposed dog food ( $5.55 \times 10$  KBq). The thyroid radioactivity increased with time after ingestion and reached its peak in 24 hours. It then dropped rapidly. The time dependence of the activity follows the equation  $B_t = 630e^{-3.4 \times 10^{-3}t} + 560e^{-0.0167t} - 970e^{-0.124t}$ . The activity in the urine peaked in 10 hours and fell afterward. It can be expressed by the following:

$$u_t = 380e^{-0.017t} + 7480e^{-0.092t} - 7700e^{-0.169t}$$

These results of thyroid and urine radioactivity served as the basis for estimating the amount of exposure in the body.

In recent years our laboratory studied the metabolism of  $^{239}\text{PuO}_2$  in the lung of a rat. The results showed that 80 percent of the  $^{239}\text{PuO}$  was in the fast sweep away phase with a  $t_{1/2}$  of 23 days and 20 percent of the  $^{239}\text{PuO}_2$  was in the slow sweep away phase with a  $t_{1/2}$  of 370 days.  $^{239}\text{PuO}_2$  could migrate to the lymph node in the chest and the half life of increase in 390 days. When the activity in the lymph node peaked, it was 1.1 percent of the plutonium deposited in the lungs. These results served as biological parameters in estimating the dose.

Yang Suxian [2799 4790 6343][5] studied the dynamics changes of  $^{210}\text{Po}$  and  $^{210}\text{Pb}$  in rats exposed to radon. After the rats inhaled enough radon to reach the pre-determined exposure level, as time moved on after they stopped taking in radon, the  $^{210}\text{Po}$  level in the bone increased while that of  $^{210}\text{Pb}$  decreased. After 300 days, an equilibrium was reached. Based on the experimental data, a function was created to serve as a reference in calibrating the  $^{210}\text{Pb}$  level in the bones of miners after they were no longer exposed to radon.

### 3. Metabolic Pattern of Nuclides in the Human Body

One of the purposes of studying radiotoxicology is to understand the toxicity of radiation to the human body. This requires animal data, as well as the accumulation of human data to the extent possible. The following is a list of some human metabolic data.

Our laboratory collected the iodine metabolism data of 916 cases who were diagnosed to have normal iodine thyroid function with  $^{131}\text{I}$ . The results showed that in the 15-24 age group the 24 hour iodine absorption rate is  $33.0 \pm \text{SD } 0.4$  percent. In the 26-50 age group, it was  $31.4 \pm 0.4$  percent. In females this runs 20 percent higher than in males, and among inland people, the figure is 20 percent higher than in people living on the coast. In 1000 cases of iodine  $^{131}\text{I}$  ingestion by people with normal thyroid functions, the amount of  $^{131}\text{I}$  discharged in the urine in 2 days is  $44.1 \pm \text{SD } 8.6$  percent. The effective  $t_{1/2}$  of the fast  $^{131}\text{I}$  discharge phase is 4.2 hours and that of the slow discharge phase is 44 days.

In radiation protection work regarding tritium, Huang Jianxue [7806 1696 1331] et al[6] observed the urine discharge pattern of 99 patients internally contaminated by tritium. It fits a three compartment model. The values of  $t_{1/2}$

are  $8.6 \pm \text{SD } 2.4 \text{ d}$  (99 cases),  $40 \pm 12 \text{ d}$  (7 cases) and 200-300 d (3 cases). They represent different metabolic regions and their differences reflect various degrees of bonding between tritium and the body tissue.

There are two methods to study the metabolism of this nuclide in the human body, measuring the activities in the urine and in the stool. Ma Ruwei [7456 1172 4850] [7] used these methods to monitor 6  $^{137}\text{Cs}$  contaminated patients. The effective  $t_{1/2}$  values are 100, 124, 54, 61, 36 and 36 days, respectively. In 3 cases, urine was measured. The effective  $t_{1/2}$  values derived from the  $^{137}\text{Cs}$  activity in the stool are 90, 64 and 35 days; in agreement with individual measurements. In addition, it was also noted that the effective  $t_{1/2}$  increases with age and weight.

There is relatively little information on metabolism of  $^{238}\text{PuO}_2$ . Zhou Yongzeng [0719 3057 1073] [8] systematically observed the plutonium discharge pattern in the urine of two patients who were accidentally contaminated with  $^{238}\text{PuO}_2$ . Based on the dynamic changes of plutonium discharged in the urine over 465 days after the incident, the amount of plutonium in the blood stream at various times was calculated. Two equations were fitted to describe the transfer from the lung to the blood:

$$A_1(t) = 0.037e^{-0.0057t}$$

$$A_2(t) = 0.032e^{-0.0049t}$$

The half sweep away periods are 131 and 141 days. The data can be used as metabolic parameters in estimating the amount of  $^{238}\text{Pu}$  deposited in the body.

#### Effects and Damage Caused by Radioactive Nuclides

One of the important purposes of radiotoxicology is to assess the hazard of radioactivity. From the angle of radiation protection, the effects of the nuclides are divided into random and non-random categories. Significant progress has been made in both areas.

##### 1. Non-random Effect

In the early stage of utilizing nuclear energy, people were most concerned with the toxicity of uranium to humans. Sun Shiquan [1327 0013 5425] [9] systematically studied and confirmed that the introduction of toxic levels of uranyl nitrate, uranium tetrafluoride, uranium dioxide and high quality uranium ore powder to animals could cause the necrosis of epithelial cells in the kidney. The animals died from kidney failure. However, when only enough uranium was given to cause apparent kidney damage, no liver changes were observed. It was when a lethal or above lethal dose was administered that liver cells were found to die. Uranium poisoning is also accompanied with neural system changes. However, the suppression of the conditional reflection to food for rats required over 20 times the dosage than that to cause kidney damage. Upon acute uranium poisoning, blood and bone marrow changes in dogs and rats were observed. Those parameters recovered faster than kidney function. Fan Jixiong [5400 4480 3574] [10] reported a case of

acute uranium poisoning. The dose in the body was approximately 93-186 mg. Clinically, the major symptom was kidney failure. The situation was improved after treatment. The kidney function completely recovered in a few years. Seven days after being poisoned, abnormal liver function was also observed. However, it recovered in 24 days. Based on the above, it is clear that in acute uranium poisoning the major damage is done to the kidney. The damage is first done to the kidney, before the liver, and damage is more serious to the kidney than the liver.

Liu Shuzhen [0491 2885 6927] [11] conducted a medical observation on employees who were in contact with uranium dust over long periods of time. It was found that the amount of 17-hydroxysteroid in the urine of the uranium workers (124 cases) was lower than that of a parallel control group and the change was significant for longtime workers, indicating decreased adrenal cortex function. Investigation of the cell immunity indicators of two groups of workers exposed to uranium dust (543 people) showed that the participating rate of the peripheral lymph cell [ $^3\text{H}$ ]TdR and the morphology transformation rate are clearly lower than those of the control group. The longer the worker worked, the more pronounced the changes were. It was also proven that this is due to the decrease of T cells.

In an early animal study in our laboratory, the injury to 53 dogs that consumed radiation fallout or early fission products was observed for 0.5 - 7.8 years. It was confirmed that, in the range of  $5.0 - 1.7 \times 10^3$  Gy in the thyroid, the thyroid function, pathological changes and dose absorbed are mutually dependent. The maximum iodine absorption rate of the thyroid (R) decreases with increasing absorption dose (D) ( $\times 10^{-2}$  Gy). It may be expressed as  $R = 2094 D^{-0.553}$ . The effective  $t_{1/2}$  of iodine in the thyroid,  $T_e$  (d), shortens with increasing absorption dose. It may be expressed by  $T_e = 1361 D^{-0.363}$ . The ratio of thyroid weight to body weight (W) also declines with the dose absorbed, which is expressed by  $W = 30.7 D^{-201}$ . From the changes of thyroid histology, the threshold for significant changes is 10 Gy. As the absorption dose increases, the extent of tissue damage becomes more severe. It is associated with the growth of interstitial fiber and different degrees of calcification and necrosis of follicles. Dose and histological changes are related. The above results served as the biological basis for the injury threshold from early fission products.

The study of the biological effect of  $^{147}\text{Pm}$  was focused on observing certain functions of the targets, bone and liver, of  $^{147}\text{Pm}$ . The study done by Zhao Jingyong [6392 4842 8673] [12] confirmed that the changes in the peripheral blood lymph cells increase with rising  $^{147}\text{Pm}$  injection dose ( $1.8 \times 10^2 - 9.2 \times 10^2$  Bq/body weight in g). There is a clear dependence between these two factors. The lower limit for causing any significant change is  $1.8 \times 10^2$  Bq/g. In the above range, only the variation of plasma glutamic-pyruvic transaminase was observed.



## 2. Random Effect

Among the studies of the random effect of radioactive nuclides, Cheng Longsheng [4453 7893 3932] [13] first reported the results of  $^{90}\text{Sr}$  induced tumor in mice. By injecting  $^{90}\text{Sr}$  at  $3.7 \times 10^4$  Bq/g body weight into ICR/JCC mice, in a two year period the tumor rate was 47.2 percent, where 41.8 percent was osteosarcoma and 5.4 percent was lymphocytic leukemia.

There is a big difference between the effect of  $^{131}\text{I}$  and that of  $^{132}\text{I}$  on the thyroid. Our laboratory studied the comparative effect of inducing thyroid tumors. The results showed that both  $^{131}\text{I}$  and  $^{132}\text{I}$  could induce various thyroid tumors in rats. As the amount absorbed increased, the rates of thyroid tumor induced by  $^{131}\text{I}$  and  $^{132}\text{I}$  both rose. When the doses absorbed by the thyroid reached 59 and 13 Gy for  $^{131}\text{I}$  and  $^{132}\text{I}$ , respectively, the tumor occurrence rate hit the maximum. The rate dropped as the dose increased further. When the thyroid tumor rates are 50, 60 and 70 percent, the  $^{131}\text{I}$  doses are 6.4, 5.7 and 5.5 times higher than those of  $^{132}\text{I}$ , respectively. This indicates that the carcinogenic effect of  $^{132}\text{I}$  is higher. These results are extremely valuable in determining injury to humans due to iodine nuclides based on the data from  $^{132}\text{I}$ .

The studies on tritium are focused on congenital malformation and genetic effect. Rats were fed tritium by Wang Jinshan [3769 6855 1472] et al. [14] When the tissue dose was 0.4 Gy, the number of spermatogenous cells in the testicle was reduced to 50 percent. The number of primary spermatocytes was reduced by 23 percent. For females, the number of primary oocytes was lowered by 35 percent and that of secondary oocytes was reduced by 63 percent. When the dose reached 1.2 Gy, the phenomenon was more severe.

According to Dong Jinchan [5516 6855 1292] [15] and Zhou Hiangyan [0719 3276 5333] [16], when comparing tritium to  $^{60}\text{Co}$  and using the survival rate of the primary oocyte of the mouse and dominant lethal mutation as the biological termination point, the relative biological effects are 3.3 and 2.8, respectively. They proved that the radiosensitivity of the sex gland is higher. Wang Zhangling [3769 2874 0109] [17] further studied the effect of tritium radiation on pregnant rats. In rats with a cumulative dosage of 0.1 Gy over 22 days, the embryo absorption rate is significantly higher. The sex ratio of the baby rats was also varied. Baby rats were found to have missing tails. The babies from mother rats with a cumulative dosage of 0.45 Gy showed occipital bone defects. The weight of the brain of the new born rats was significantly lower than that of the control group. These results indicate that we should pay attention to the genetic effect caused by tritium.

Beijing Medical School and other laboratories quantitatively studied the effect of tritium on the mutation of the peripheral blood lymph cell chromosome. Rao Yongqing [7437 3057 3237] studied the dose effect relation for compounds such as  $\text{HTO}$ ,  $[^3\text{H}]\text{TdR}$ ,  $[^3\text{H}]\text{thymine}$ ,  $[^3\text{H}]\text{UdR}$  and  $[^3\text{H}]\text{lencine}$  which could cause the mutation of chromosome of lymph cells. The relation between the dose absorbed ( $d$ ) ( $\times 10^{-2}$  Gy) and the break number/ cell ( $Y$ ) fits the model  $Y = Kd^h$ . The difference in the effect of these five tritium compounds provided an important clue for the further study of dose effect relation.



In the study of random effect, the most important result is a combination of animal model studies and radiation epidemiology survey. Our laboratory, in collaboration with Tongren Hospital, conducted a health survey among a few patients who were taking  $^{131}\text{I}$ . Shen Zhezong [3088 0772 0022] [18] evaluated the health of thorium workers. Chen Xingan [7115 5281 1344] [19] monitored the thorium level in the lungs of thorium workers and predicted the occurrence of lung cancer. Sun Shiquan [20] studied radon induced lung cancer. They all made very good progress in their fields.

The study of radon induced lung cancer not only affects the health of the miners but also makes the public aware of the hazard of radon in the house. Wang Lihua [3769 7787 5478] [21] proved that after cumulatively being exposed to radon for 2600 and 5000 work months the rats developed lung cancer in 95 and 473 days, respectively. Sun Shiquan surveyed the Yunxi mine. The condition of the mine was very poor before the Revolution. In 1972 the pit of the highest radon concentration was measured at 29 Bq/l. In the past 20 years, 1200 people died of lung cancer. 90 percent of them were miners in the pit. The death rate of the miner is 34.9 times higher than the average. It increases with the time working in the pit. The radon concentration in the three mines in descending order is: old plant > Ma mine > Song mine. Based on statistics, the lung cancer death rates in these three mines since 1950 are 26, 8.4 and 4.5 higher than the average, respectively. If we include the miners working in these mines before the Revolution in the statistics, the lung cancer death rates are 45.8, 43.4 and 17.5 times higher than the average, respectively. This fact indicates that radon concentration is related to the lung cancer death rate of the miners. We are also aware that arsenic is also an important factor in inducing lung cancer in miners.

#### Study of Drugs for Accelerated Removal

In radiotoxicology, study of drugs for emergency treatment and accelerated removal is a practical field. After long term research, some feasible drugs and methods have been introduced. Several new complexing agents were designed and developed for pharmacological and toxicological studies.

##### 1. Verification and Improvement of Effective Drugs

Studies are done to verify and improve several dozens of drugs that have already been proven effective in other countries. These drugs include mild laxatives, absorption blockers, acidifying agents, complexing agents, biological blockers, diuretics and antidotes.

Our laboratory conducted a bench top experiment and human study on using potassium iodide to block the absorption of iodine by the thyroid. The emphasis was placed on comparing the difference in its effectiveness against  $^{131}\text{I}$ ,  $^{132}\text{I}$  and mixed iodine nuclides. It was found that its block effect is significantly lower against  $^{132}\text{I}$  as compared to  $^{131}\text{I}$ . It also clearly showed that the timing of taking the medicine is a key factor affecting the effectiveness of the treatment.

Wang Yumin [3769 3768 3046] studied the drug for acute uranium toxicity--Tiron[23]. The result showed that the animal survival rate could reach

90-100 percent using Tiron. In combination with  $\text{NaHCO}_3$ , all animals given a lethal dose could be saved.

Several laboratories in China investigated the use of DTPA to remove nuclides of rare earth elements, thorium, uranium, plutonium and elements above, and measures to reduce the toxicity of DTPA. The results showed that it is a highly efficient complexing agent capable of accelerating the removal of over 20 kinds of nuclides. The toxicity of the zinc salt of DTPA is lower than that of its calcium salt. In addition, it is still effective by inhaling the drug at a lower dose which also reduces its toxic effect.

Our laboratory, in collaboration with the Institute of Atomic Energy, studied the use of sodium alginate to stop the uptake of radioactive strontium. An animal experiment confirmed that sodium alginate extracted from the algae in the South China Sea is a highly effective blocking agent against the uptake of radioactive strontium. After going through animal toxicology tests, evaluation of effects on humans, pilot production, pharmacological analysis and human effectiveness assessment, a drug for human consumption has been developed.

## 2. Studies on Newly Created Drugs

Shanghai Institute of Pharmacology, Shanghai Institute of Industrial Hygiene and Huabei Institute of Radiation Protection made significant progress in developing new drugs for the rapid removal of uranium, thorium, plutonium, cerium and strontium. Their approach was focused on compound structure and removal efficiency.

Shanghai Institute of Pharmacology and Shanghai Institute of Industrial Hygiene jointly designed several dozen complexing agents for the rapid removal of thorium and discovered a few effective compounds. The most effective drug to remove thorium is quinolinic acid. Systematic pharmacological and toxicological studies proved that it is more effective than DTPA in removing thorium. It is also somewhat effective in removing plutonium, cerium, tin, promethium, zirconium, lead, mercury, zinc and cadmium. It is a new "wide spectrum" complexing agent following DTPA.

The study done by Huang Qi [7806 3825] [24] also proved that H - series compounds are effective in promoting the removal of plutonium. H - 73-10 appeared to be most effective. At im 400  $\mu\text{mol}/\text{mouse}$  1 hour after plutonium poisoning, it was found to be most effective. It has a wide effective dose range. At 0.2  $\mu\text{mol}/\text{mouse}$  the effect was obvious, which is only 1/50 of the equivalent dose of DTPA. Despite the fact that it is more toxic, its treatment index is 352 which is better than DTPA (52). In addition, it is also effective in the removal of uranium and thorium.

Based on the affinity of phosphonic acid compounds, Shanghai Institute of Pharmacology successfully designed and synthesized ethylaminobutyldiphosphonic acid (S186). It was confirmed by Luo Meichu [5012 2734 0443] that it is the most effective phosphonic acid compound in promoting the rapid removal of strontium. After taking radioactive strontium, S186 was given immediately at

im 600 mg/kg body weight.  $50.5 \pm \text{SD } 2.4$  percent of strontium was discharged in the urine. The amount of strontium left in the bone was  $24.2 \pm \text{SD } 1.2$  percent. In the control group, the numbers were  $7.5 \pm \text{SD } 1.0$  percent and  $66.4 \pm \text{SD } 4.0$  percent, respectively. The treatment is more effective than BADE. After obtaining animal toxicity and human safe dosage data, it was used on several cases of  $^{90}\text{Sr}$  contamination. Increased strontium level in the urine was also observed.

In recent years, the Shanghai Institute of Pharmacology has addressed the research of uranium removal drugs. Based on the coordination characteristics of titanium-iron compounds, several dozens of compounds have been designed. Three compounds were found to be effective.

It is worthwhile to point out that in the new drug research described above, in addition to pharmacological and toxicological studies, investigations on the pharmacokinetics, drug caused malformation and mutation, and observation of metabolism of minute amounts of elements in the body were also included. The results will serve as a reliable basis in clinical applications.

This paper summarizes the major progress in radiotoxicology research in China which includes metabolism, injury and drug development. From the trend of radiotoxicology research and the weakness in our activities, the study of in-vivo dosimetry, comparative toxicology and complexing effect of harmful factors in the environment must be strengthened. We expect to make more advances in the dose effect area in order to reveal the pattern under which radioactive nuclides harm the human body and contribute to the safe utilization of nuclear energy.

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12553/7358

## NATIONAL DEVELOPMENTS

### APPLICATIONS OF BIOTECHNOLOGY IN CHEMICAL INDUSTRY REVIEWED

40081010 Beijing SHIYOUHAUGONG [PETROCHEMICAL TECHNOLOGY] in Chinese Vol 16, No 1, Jan 87 pp 53-56

[Article by Song Jian [1345 0256], National Institute of Chemical Engineering Research, Beijing]

[Text] Biotechnology, also known as bioengineering or bioengineering technology, is a new and upcoming technological field developed on the basis of molecular biology and cellular biology in the early seventies. The birth and rapid growth of biotechnology mark one of the most important milestones of the new industrial revolution.

Biotechnology is a fusion of genetic engineering, cellular engineering, enzymatic engineering, fermentation engineering and biochemical engineering.

If recent breakthroughs in this field are any indication of its potential, biotechnology appears to promise new and better solutions to the impending threats of shortages of energy, food and other natural resources as well as environmental pollution. In addition, biotechnology is expected to assist in hastening the progress in the pharmaceutical industry, crops and livestock farming, fishery, food industry, energy industry, chemical industry, and metallurgy. Mounting evidence suggests that the development of this new technology will bring major rewards for society.

#### I. World Roundup

With the progress in the development of recombinant DNA, cellular fusion, and enzymology, it is most likely that in the near future biotechnology will be able, not only to provide starting materials for the chemical industry and bring about their conversion into end products at reduced costs on large scales; but also improve classical chemical syntheses or replace them with energy-efficient and pollution-free processes. Therefore, it is not surprising that there is worldwide attention focused on possible biotechnological applications in the chemical industry. Chemical industry giants, such as Du Pont, Monsanto, and Dow Chemicals of the United States, Hoechst A.G. of West Germany and the British ICI all have invested heavily in research on biotechnological application in chemical industry. Their efforts have paid off; many a biotechnologically manufactured product has become commercially available. In 1983, the sales of biotechnological products totalled \$1.6 billion<sup>1</sup> in the capitalist world, the share of industrial chemicals was \$640 million<sup>1</sup>.

The uses of biotechnology in the chemical industry are many: to improve or renovate obsolete chemical synthetic processes, to develop new biochemical products, to save energy and solve associated pollution problems. At present, it is commonly used in producing industrial feedstocks, amino acids, monocellular proteins, biopesticides as well as in waste water treatment.

#### 1. Applications in Producing Raw Materials and Other Industrial Chemicals

Ethanol, acetone, and n-butanol are traditionally made by fermentation. Ethanol can now be made, with great savings in production facility investment and operation cost, by a continuous process using a high efficiency yeast which converts glucose into the alcohol. In many countries, ethanol is derived from wood-pulp and other agricultural scrap. Enzymatic conversion processes also enhance the competitive edge of biotechnologically manufactured acetone and n-butanol in the market. The French Technip company is scheduling to open its enzymatic production lines for acetone and n-butanol in 1986 [sic], whereas in Switzerland these two materials are made from fermentation of hydrocarbons.

To the list of biotechnologically synthesized industrial raw materials of ethanol, n-butanol and acetone, should be added decanedioic acid, an essential ingredient in producing nylon and fragrances. Its conversion from normal alkanes by micro-bes-catalyzed oxidation has been successfully developed. Other production examples include the conversion of alkanes into longer-chain dicarboxylic acids and diols as well as the synthesis of 2,3-butanediol, the starting material for synthetic rubber, from carbohydrates. A U.S. biotechnology firm, Cetus, commenced a study to prepare ethylene oxide and propylene oxide starting from ethylene and propylene respectively, by fermentation in 1981. The company believes that enzymatic production of propylene oxide will begin before the decade's end. This fermentation process will phase out the conventional chemical synthesis of epoxides, which has suffered the maladies of serious fire and explosion hazards, in addition to generating toxic wastes. The new approach allows savings in energy, materials and investment in capital equipment; it is pollution-free as well. The United States is also pursuing the following projects: conversion of 2-hexene dicarboxylic acid from toluene using microbial enzymes; synthesis of polyesters with characteristics similar to that of polypropylene oxide, from starch and carbohydrates by fermentation; production of indigo blue using microbes obtained from recombinant DNA. A scientist at the Cetus Corporation has devised an enzymatic method for making ethylene oxide and propylene oxide from straight chain alkenes and then, carrying the intermediates on to the end products, plastics. This process not only reduces production cost, but also generates fructose as a by-product. Japan has built the world's first reactor to convert methacrylonitrile (propenyl cyanamide) into methacrylamide (butenoic acid amide) using a biological catalyst in the place of the conventional copper catalyst. The British Imperial Chemical Industries has developed a fermentation process to manufacture polyhydroxybutanoic esters from biomass; they have also successfully derived methanol, formic acid, acetic acid and butanoic acid from organic wastes. According to a recent Japanese forecast, biotechnology will account for 20 percent of the total chemical industry production by 1995, and 50 percent by 2000<sup>2</sup>; the biosynthesized industrial chemicals will hold a 15 percent share of the total output of the biotechnological industry worldwide and is valued at \$60 billion a year.



The traditional fermentation industry in China is well established. Ethanol, acetone and n-butanol have been commercially produced since the early fifties. We have also launched major projects to develop fermentation processes for manufacturing glycerin, 2, 3-butanediol and glycol.

## 2. Applications in the Production of Amino Acids.

Amino acids are consumed in many ways such as food and animal feed additives, flavor enhancers, nutritional supplements, metabolism stimulants, pharmaceuticals, cosmetics as well as detergents.

The manufacture of amino acids by fermentation, first developed in the late fifties, is a new and rapidly growing industry. The amino acid constitutes a major type of product of the microbiological engineering productions. Out of the 22 known amino acids, 18 are produced either by fermentation or enzymatic processes in many countries. Japan is the largest amino acid producing country with an annual production of approximately 109,000 tons. The world annual output of amino acids has been increasing at a rate of 5-10<sup>3</sup> percent for the last two decades. In the past several years, foreign producing countries have redesigned the bacteria or microorganisms producing threonine, arginine, tryptophane, histidine, lysine and leucine through genetic engineering and cell fusion. The newly "mutated" bacteria have already been employed for manufacturing threonine and tryptophane and have greatly increased the production level.

At present, foreign companies are directing their major efforts to search for better processes that require decreased fermentation periods. A food example is the new fermentation process for lysine. It was previously isolated from the acid hydrolysis of hog fibrin; a process that has relative low yields and high costs. It is now possible to produce lysine with ever decreasing incubation time with the modern microbiological process. Because of its reduced reaction time, this process affords higher yields at lower costs, resulting in handsome economic returns.

Since the first production of glutamic acid in 1965, the Chinese amino acid industry has gradually developed into an integrated producing system. In addition to glutamic acid, lysine and leucine are manufactured domestically in moderate quantities; many other amino acids are on preliminary or secondary production trial runs.

## 3. Applications in Producing Monocellular Proteins

With the daily increase in world population and progressive decrease in farming land, the sources of animal and plant proteins are getting scarce and the food protein shortage has become a very serious problem. It is estimated that when the world population reaches 7.6 billion by the year of 2000, there will be a food protein shortage of 22 million tons a year. Since the protein content is as high as 45 to 55 percent (dry weight) in microbes, the fermentation procedure for making monocellular proteins has evolved into an important source of food and animal feed proteins.



The U.S.S.R. is the largest monocellular protein producing country today. Their annual output is 1.2 million tons which is expected to be raised to 11-12 million tons during the next several years. Other East European countries and Cuba also have manufacturing facilities with production capacities of 10,000 tons or more in operation<sup>4</sup>.

Straight chain alkanes, diesel fuel, ethanol and methanol can all be used as the raw material for monocellular production and the process started with methanol is the most desirable. The product derived from methanol is composed of 80 percent or more proteins and enriched in amino acids and vitamins. Its major use is in animal feed stock. The competition in this field is fierce: The British ICI has just completed a methanol protein plant with a production capacity of 75,000 tons a year. A large methanol protein plant is under construction in the U.S.S.R.; its projected annual production is 0.3 million tons by 1990 and 3 million tons by 2000. The Italians are designing a similar plant with smaller capacity--100,000 tons a year. A West German plant with projected capacity of 1000 tons has already reached advanced trial run stage.

We have made satisfactory research progress in synthesizing monocellular proteins from methanol as well as bacterial proteins, as a feedstock supplement, from vitamins. For example, a process to derive feedstock with a protein content of 8-10 percent from plant stalks has been developed; its application in commercial production is under trial.

#### 4. Enzymes and Their Applications in Organic Synthesis

Enzymes are proteins specialized to catalyze biological reactions. They are the nucleus of bioengineering. None of today's biotechnology can be carried out without the assistance from enzymes.

There are six principal classes of enzymes: oxido-reductases, transferases, hydrolases, lyases, isomerases and ligases.

Of the more than 200 known enzymes, approximately 300 are commercially available. Enzymes such as  $\alpha$ -amylase, glucoamylase, proteinases, lipase and glucose isomerase are in mass production today.

The enzymes have numerous industrial applications. The alkaline proteinase, used in enzymatic detergents, for example, tops the sales of enzymes in the international market. The chemical industry is employing enzyme catalyst to solve difficult chemical synthetic problems. For example, the synthesis of methacrylamide (butenoic acid amide) catalyzed by cupric pentanoate is carried out under high temperatures and pressures; reaction conditions that require complex machinery and equipment, consume a great amount of energy and consequently, result in high operating costs. Certain foreign chemical companies are experimenting with the preparation of methacrylamide (butenoic acid) catalyzed by an immobilized enzyme. Japan has built a plant, using this new technology, to produce 4,000 tons of methacrylamide (butenoic acid amide) a year. Because this enzymatic procedure allows the reactions to be carried out under atmospheric pressure and ambient temperature, the large amount of heavy equipment usually needed by conventional manufacturing processes can

be reduced and the mild reaction conditions mean savings in energy. That is to say that the same product costs much less to produce by this new enzymatic process. Reports from the United States and Japan indicated that the plastics processing industry and the synthetic fabrics industry there are studying the feasibility of making alkene oxides by the enzymatic approach. The Japanese Sumitomo Company is using a new enzymatic technology to produce a water-soluble hydrolytic protein from the hydrolysis of gelatin, which can be selectively absorbed by the scalp, protect the hair and is a nourishment for the skin; it is a most ideal ingredient for cosmetics<sup>5</sup>. SHOWA Electronics recently developed an enzyme displaying high activities at low temperatures. This enzyme is used in manufacturing a new kind of detergent which exhibits stronger cleaning power than conventional ones<sup>6</sup>. Furthermore, a new sweetener, made by an enzymatic process, is reported to be 150 times as sweet as sucrose.

Most enzymatic engineering research projects are directed at the enzyme immobilization technology. To simplify the isolation and purification steps in enzyme production, efforts are devoted to the study of immobilizing enzyme-producing cells as well. In addition, the redesign and chemical modifications of enzyme molecules have also attracted some research interests.

We have a fair-sized enzyme production industry and commonly used enzymes such as  $\alpha$ -amylase, glucoamylase, glucose isomerase, proteinases, lipase and urease are among those being mass manufactured. Our fermentation industry is well-established; for instance the continuous fermentation process starting from the liquification of starch by  $\alpha$ -amylase, through the intermediate sugars to give ethanol and the use of alkaline proteinase in detergent. Cellulose is one of the most abundant natural organics; 400 million tons of rice straw, wheat stems, corn stalks and cotton seed pods are harvested each year in China. However, we have not been able to fully make use of this resource. The cellulose can be degraded by cellulase to afford glucose, which in turn can be converted by microbes into monocellular proteins, ethanol, amino acids, and organic acids. We have made considerable progress in biological nitrogen-fixation research using the nitrogenase as well.

Our study on enzyme-immobilization technology was first launched in 1970; the immobilization process has been applied in manufacturing nucleotides, fructose syrup, malic acid and aspartic acid. In addition, we succeeded in immobilizing the glucose isomerase by resin absorption and gel permeation techniques. The research to immobilize proteinases is underway and much progress has been made in cell-immobilization study as well.

##### 5. Applications in Producing Organic Acids

Organic acids such as citric acid, lactic acid, succinic acid,  $\alpha$ -ketopentanoic acid, fumaric acid, malic acid, gluconic acid, tartaric acid, fatty acids and salicylic acid are produced by fermentation. The biotechnology is widely used in making organic acids in the United States and West European countries, for example, malic acid is now produced by an immobilized-enzyme process. The most important organic acid is citric acid. Its annual output worldwide is 400,000 tons; 150,000 tons by European Common Market countries, 150,000 tons by the United States and approximately 10,000 tons by Japan. The production is growing at an annual rate of 5-10 percent.

The commercial production of organic acids in China started with the introduction of lactic acid in 1944. We also have over 30 years experience in researching and optimizing the citric acid fermentation process. However, our yields and recovery rates in lactic acid and citric acid fermentations have consistently been lower than foreign competitors. Therefore, our future efforts should be concentrated on selecting and cultivating high yielding enzymes for lactic acid and citric acid, developing new fermentation methods and improving isolation and purification procedures as well as modernizing related equipment. Another problem that needs our immediate attention is the separation of isocitric acid from the desired product in the citric acid fermentation process using petroleum as the starting material.  $\alpha$ -Ketoglutaric acid, itaconic acid and kojic acid are also produced domestically. Fermentation processes of certain other organic acids are under investigation.

## 6. Applications in Biopesticides

Chemical pesticides usually leave behind highly toxic residues, which persist in the environment and present a very serious health hazard. Unlike chemical pesticides, biopesticides are neither toxic nor polluting; in addition, they are very difficult for insects to adapt to by mutation. For these obvious advantages, biopesticides are attracting more and more interest.

The biopesticides include bacterial pesticides, fungal pesticides, viral pesticides and antibiotic pesticides. In the bacterial pesticide market, the United States has already introduced three new products. The Japanese output of bacterial pesticides is 4,000 tons a year. The most potent of these, based on *Bacillus thuringiensis*, is effective against different kinds of insect pests but exhibits no adverse effects upon human and animals. It is commercially produced in the United States, France, and the U.S.S.R.. Genetic engineering experiments are being carried out to insert the viral genes of *Bacillus thuringiensis* into *E. coli*. so that the virus against *Bacillus thuringiensis* can be mass produced and used as a pesticide. Japan is also exploring the mass production process for the virus that can eradicate *Bacillus popilliae*. In the United States, DDT has been phased out by biopesticides and bio-herbicides.

In the early fifties, Japan introduced a number of antibiotic pesticides such as the antibiotic pesticide against rice blast, Spring Thunder mycin and oxygenated mycin. The international biological field was much impressed and joined in the research and development of antibiotic pesticides and herbicides. Subsequently, Japan marketed many new and better agricultural antibiotics to be used against crop diseases and insects.

Furthermore, a new class of biosynthesized agricultural agents, such as soil treatment agents and leaf stimulating agents, has been introduced in the industrialized countries to improve the soil and increase the yield.

In recent years, our agricultural authorities have conducted extensive research to study the feasibility of using bacteria, fungus and viruses in the prevention and control of insect pests, their possible applications and mass production processes. It was determined that this biopesticide approach has achieved a success rate of over 80 percent in preventing and controlling pests. A

bacillus with a specificity for gypsy moth, cultivated domestically, is very effective in controlling insects on aquatic rice crops. The Bai Jiang [4101 0304] germ is one of the most commonly used fungal insecticides; it is very effective against insect pests in woods and forests. A good example of viral pesticides is the cotton moth virus No V-273. It is used to protect the cotton crop and has achieved remarkable results. Its pest control rate is as high as 94 percent, compared to the 73 percent of DDT under similar conditions.

The study of producing antibiotics by fermentation was initiated in China in the sixties, and Jing Gang Shan [0064 1481 1492]-mycin was first prepared in the seventies. In recent years, new antibiotics, including gibberellin, Gong Zhu Ling [0361 0031 1545]-mycin have been introduced. We are also manufacturing Spring Thunder-mycin, oxygenated mycin and anti-inflammatory mycin in moderate quantities. New antibiotics having better therapeutic qualities, such as Liu Yang [3461 7122]-mycin and Pandamycin are under development.

## 7. Applications in Environmental Protection

Current research is mostly devoted to the treatment of toxic substances in industrial waste-water by immobilization processes and the manufacture of "super bug" to treat large area pollution.

The British ICI was able to decrease the cyanide content in cyanide-containing waste-water from 3 percent to 1 ppm using a microbial treatment process. Japan has cultivated an organophosphatase to decompose organothiophosphorous compounds, a class of toxic substances very difficult to break down. The United States has developed a "super bug" capable of eating crude oil spills. A biotechnological treatment procedure to degrade organochlorine compounds such as pentachlorophenol has been developed. In addition, microbes can be used to, either recover precious metals or remove poisonous metals from industrial waste water. Many research projects are also directed to derive methane and monocellular proteins from industrial and urban waste water.

We have made some progress in the treatment of waste water containing chemical pesticides, for instance, procedures have been established to decontaminate water polluted with Fen Xin Ning [4720 6907 1380] [brand name] and Chu Chong Ju Zhi [7110 5849 5468 7927].

## II. Recommendations

### 1. Grasp the Application of Biotechnology in the Research and Development of Industrial Chemicals

Chemists and chemical engineers should explore the feasibility of replacing conventional chemical syntheses starting with materials usually in short supply, those which follow inefficient pathways or require harsh reaction conditions and those which cause severe pollution with compatible biological processes.

At present, special attention should be given to the development of raw materials for the chemical industry such as ethylene oxide, propylene oxide, ethylene glycol and acrylic acid; food and animal feed supplements and polymers like polyacrylamide and polyhydroxybutanoic esters. We should emphasize the development of ethanol fermentation from pentoses, cellulose, semicellulose, and wood-pulp as well.

## 2. Redouble Our Efforts in Improving the Product Isolation and Purification Procedures for Biotechnological Processes

The requirements of isolation and purification of biologically synthesized materials are very demanding since the product concentration in the crude reaction medium is generally very low where undesired side products and other contaminants are present in relatively high concentrations. Furthermore, the activities of microbes can easily be impaired by heating or chemical reactions of certain reagents. All these considerations contribute to make our task even more formidable. The Chinese chemical industry is well-versed in chemical isolation and purification procedures. We should apply our know-how in this field to improve product isolation and purification steps in biotechnological processes. It is imperative that special research efforts be made to optimize the conditions for medium removal and to upgrade equipment.

## 3. Grasp the Application of Biotechnology in Industrial Waste-Water Treatment

Large quantities of toxic wastes are generated by the chemical industry each year and some of these materials, such as certain aromatic compounds, organochlorides and pentachlorophenol as well as pesticides like malathion and moth killers, are very difficult to degrade, making their treatment practically impossible. For the well-being of mankind, it is important that chemical wastes are properly disposed of and this aim can best be achieved by biotechnological processes. First of all, we ought to develop and perfect conventional biochemical treatment procedures so that the treatment can be conducted with high efficiency, at low cost and using less land for treatment facilities. Further developmental work should be directed to select and cultivate enzymes with specificities for organochlorides, organophosphates and other not readily degradable toxic substances and their immobilization procedures for waste treatment.

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12817/7310

## SCIENTISTS, SCIENTIFIC ORGANIZATIONS

### GENE ENGINEERING EXPERT CHEN ZHANGLIANG PROFILED

40081023a Beijing GUANGMING RIBAO in Chinese 10 Sep 87 p 1

[Article: "Chen Zhangliang [7115 4545 5328], Who Received a Doctorate in the United States, Is Hired as Assistant Professor by Beijing University--Dedicated to Serving His Country, He Receives Assistance From Many Areas--Month After Returning to China, With Assistance by Relevant Departments of the State, He and Several Professors Cooperated To Establish a Biological Genetic Engineering Laboratory on a Preliminary Scale and Have Completed Some Basic Experiments"]

[Text] Twenty-six year old Chen Zhangliang, who returned just one month ago from studying abroad, has been hired as an assistant professor in the Biology Department at Beijing University, something seldom seen in China's universities, which are full of talented people.

Relevant departments in the state were extremely supportive of Chen Zhangliang and provided him not long ago with adequate scientific research expenditures. He cooperated with several professors in the Biology Department at Beijing University to establish a biological genetic engineering laboratory on a preliminary scale within a rather short period of time and they have completed some significant basic research.

Chen Zhangliang obtained a Doctorate from the University of Washington. Most people in China are unacquainted with him, but his advanced scholarly accomplishments have attracted attention from biotechnology experts all over the world. In June 1987, he presented a 30-minute report at the world-famous United States High Level Gordon Research Conference. Among S&T circles, being invited to participate in this conference, which represents developmental directions and the newest achievements in the life sciences in the United States, is in itself a special honor, and Chen Zhangliang was just studying for his doctorate as a graduate student at the time.

This young Ph.D. was born to a peasant family in Fuqing County, Fujian Province. Because of his impoverished family situation, he did not begin school until he was 9 years old, but his strength of will from an early age and his special brilliance and sensitivity meant that his accomplishments in his studies always placed him at the top of his class. He passed the examination for admission to the South China College of Tropical Corps in 1978 and dedicated



himself to the noble ambition of using science and technology to transform the backwardness of the rural economy. He enrolled as a graduate student at the University of Washington in the United States in 1983 and began his pursuit of plant genetic engineering, a new and advanced technology.

For four long years, Chen Zhangliang studied and worked at "overload." In 1985, the Journal of the European Molecular Biology Society published 24-year old Chen Zhangliang's first article, which announced the first successful use of genetic engineering methods to transplant a soybean protein gene into dwarf morning glory (a member of the Solanaceae family) and achieve the expression of the soybean protein gene in the dwarf morning glory seeds. This means that not long from now, similar methods can be used to transplant soybean protein genes into other farm crops to increase the protein content of these crops and achieve the necessary amino acid balance. In November 1986, Chen Zhangliang also presented another important paper at the United States National Academy of Sciences concerning the first discovery of the ability of a strand of genetic material (DNA) to control the expression of the genetic characteristics of a plant in its seeds, and that this strand of DNA increased the unrelated genetic expression capacity during a particular stage of seed development by more than 20 times. This discovery is of major significance for future research on the high-level expression of genes of economic value in unrelated plants. Because of these outstanding research achievements, Chen Zhangliang received his Ph.D. in July 1987, one and a half years ahead of schedule.

Should he accept an offer of a position in any of several United States corporations or colleges and universities to continue with his scientific research under superior material conditions, or should he return to the motherland and strive to invigorate science and technology in China? Chen Zhangliang was faced with two choices.

Chen Zhangliang knew deeply that the biotechnological research to which he was preparing to dedicate his life was one of the newest and most advanced technologies in the world. It is capable of continually creating new improved varieties and viological manufactured products and could, if integrated with conventional agricultural technologies, provide many times the benefits with half the effort. There also are broad prospects for the utilization of biotechnologies in other realms like medicine, light industry and so on. Now is the time when China urgently needs people with biotechnological skills, and a young person who had grown up drinking the milk of the peasants and who had depended on the people to raise him into an adult should contribute all of his brilliance and talent to his own nation. As a result, in early August 1987, Chen Zhangliang had barely received his doctorate when he returned quickly to China and made his "home" at Beijing University.

After returning to China, Chen Zhangliang did not even have the time to visit his parents before he buried himself in laboratory construction and key experiments. When reporters went to see him, he stated sincerely that after returning to China, he had received substantial assistance in his work arrangements from the relevant departments of the state and Beijing University and that

a "green light" had been turned on everywhere to create very good scientific research conditions. The comprehensive cooperation by leaders at Beijing University and the Department of Biology and by Assistant Professor Pan Naisui [3382 0035 4482], Engineer Liu Chuqing [0491 2504 3237] and others assured the continuity of the research work so that the advanced technologies he had studied abroad could be utilized as quickly as possible. He believes that unity and cooperation by everyone may make it possible for the laboratory to complete the tasks assigned by the state within a short period of time and that they can make a contribution to future development of biotechnology in China.

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## SCIENTISTS, SCIENTIFIC ORGANIZATIONS

### LIFE SCIENCES CENTER FOUNDED IN SHANGHAI

40081023c Beijing PEOPLE'S DAILY (OVERSEAS EDITION) in Chinese 10 Oct 87 p 4

[Article: "Shanghai To Build Life Sciences Center To Centralize the Skills and Heroism of Everyone and Make Breakthroughs in Advanced Sciences"]

[Text] The Chinese Academy of Sciences has decided to establish a Life Sciences Center in Shanghai. This news was revealed at the Shanghai Life Sciences Center Expert Demonstration Conference held on 9 October 1987.

This center is being established to centralize the skills and bravery of all of the main biological research institutes in Shanghai and to strengthen research in advanced fields in the life sciences. The center will recruit a group of accomplished middle aged and young life scientists for research to form an advanced life sciences research staff as quickly as possible. The center also will undertake international scholarly exchange activities.

Shanghai is China's primary base for research in the life sciences and Feng Depei [7458 1795 1014], Zhang Xiangtong [1728 7449 2717], Tan Jiazhen [6151 1367 2823] and other accomplished life scientists are there. The Chinese Academy of Sciences' Institute of Biochemistry, Institute of Physiology, Institute of Microbiology and other organizations are located in Shanghai. Moreover, the Fudan University Institute of Genetics directed by Tan Jiazhen also is famous in China and abroad.

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SCIENTISTS, SCIENTIFIC ORGANIZATIONS

CHINESE ASSOCIATION OF MEDICAL FOUNDATIONS ESTABLISHED

40080123b Beijing GUANGMING RIBAO in Chinese 6 Sep 87 p 1

[Article: "The Chinese Association of Medical Foundations Is Established in Beijing"]

[Text] The Chinese Association of Medical Foundations was established in Beijing on 5 September 1987.

Chairman Zhu Xuefan [2612 1331 5400], said at the Founding Conference of the Chinese Association of Medical Foundations that the association was a non-governmental non-profit public interest organization. Its mission is to develop the people's medical health care industry and to assume responsibility for organizing nongovernmental medical prevention and exchange activities with international medical science and technology. Its concrete responsibilities are to accept, manage, distribute and utilize contributions of capital and materials from China and foreign countries; to develop cooperative relationships between international friendship groups and individuals and medical circles; and to provide medical and public health construction and service programs for the people's health.

According to the information, the Chinese Association of Medical Foundations has a corporate status. The deputy chairmen are Qian Xinzong [6929 0207 1813] and Cui Yueli [1508 2588 3680], and the association president is Li Shanqing [2621 0810 0615]. The board of directors is composed of 47 Chinese and Western medical specialists and three administrative cadres.

Diao Zhongxun [0431 0112 8113], Chen Muhua [7115 1970 5478], responsible persons from the Ministry of Public Health, the Ministry of Finance, the Ministry of Civil Affairs, the United Front Work Department, the Beijing Municipal People's Government, the Department of General Health, the People's Bank of China, the Bank of China, the Government Offices Administrative Bureau, the Chinese Association for the Promotion of International Friendship, the Chinese Red Cross Society, the Chinese Academy of Medicine and other relevant units as well as some foreign reporters participated in the founding conference held on 5 September.

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